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NOTES ON SOME AMERICAN SPHECINÆ (HYM.).

H. T. FERNALD,
Orlando, Florida.

In 1913 it became possible for the writer to study the types of American Sphecinæ now in Europe as far as it was possible to locate them. They are widely scattered in the different European collections and my studies took me from Naples to Lund and from Vienna to Oxford. In all, eleven places were visited but I was unable to visit Genoa, Geneva and Copenhagen where a few presumably are. Nor could I locate the Spinola collection. Most of Lepeletier's Sphecid types seem to have been described from this collection and I supposed the types would be in Paris. This proved not to be the case and Lepeletier's descriptions, while not particularly brief, are models, in this group at least, for giving only non-distinctive characters. In most cases, therefore, his species remain unrecognized.

Genus **Chlorion** Lat. (**Sphex** of many authors.)

The reasons for changing the generic name *Sphex* to *Chlorion* have been given by the writer in Entomological News, xv, 117, 1904 and xvi, 163, 1905, and perhaps more clearly in Proc. U. S. Nat. Mus., xxxi, 292, 1906. It is unnecessary, therefore, to consider them here. The position taken in those articles is fully sustained by Opinion No. 32 of the International Commission on Zoological Nomenclature.

Chlorion (**Chlorion**) **cyaneum** Dahlb. This species has been and still is often referred to as *Chlorion* or *Sphex coerulea* L. This is incorrect. Linné in the tenth edition of the Systema Naturæ, p. 571, described *Sphex coerulea* from "America

meridionali." Kohl has expressed the opinion that this description refers to some southern species of *Pepsis*. In any case it does not agree with the species here concerned. In the twelfth edition of the Systema Naturæ Linné repeats this description on page 947 as species No. 38, while on page 941, as species No. 2, he describes another *Sphex coerulea* from "America septentrionali" which agrees with our North American species fairly well. The name cannot hold, however, for the other one (on page 947) is the same, word for word, as the one in the tenth edition which therefore has priority. Catesby, De Geer and Drury seem also to have written about the *coerulea* No. 2 of the twelfth edition but use either *coerulea* or no name at all. Fabricius recognizes both of the Linnean species, which in his Systema Piezatorum he places in the genus *Pepsis*, by references to the twelfth edition of the Systema Naturæ, but seemingly has noted the duplication of the name for he renames the preoccupied one, *cyanea*. This would seem to provide the species with a name, but in the Fabrician collection at Kiel, arranged both by name and number to correspond with the Systema Piezatorum, and presumably so arranged by Fabricius himself, are three specimens, placed under that name and number, which upon examination proved to be the common *Chalybion cyaneum* Dahlb, one of the mud daubers, and entirely different from the insect under consideration.

If Fabricius was acquainted with Linné's specimens and correctly identified his own, it would follow that neither Linné's nor Fabricius' names could apply here. In any case the Fabrician one cannot.

The first name to become available for the species is that given by Dahlbom (Hym. Eur., I, 24, 1843) who gave it the name *Chlorion cyaneum*. As he recognizes the Fabrician species also, as *Chalybion cyaneum*, with references to Linné, DeGeer and Fabricius, no confusion of the two is possible. Accordingly, *cyaneum* is the first available name for this insect and as it is still placed in the genus *Chlorion* its name is *Chlorion* (*Chlorion*) *cyaneum* Dahlb.

Chlorion (**Priononyx**) **striatum** (Sm.). The type of *Sphex* (*Priononyx*) *laerma* Cam. in the British Museum upon examination proves to be this species and the "?" before the reference to it on page 335 in my paper (Proc. U. S. Nat. Mus., xxxi, 1906) can be deleted. In Vienna, Kohl has labelled specimens of

striatum as *johannis* Fab., showing his opinion as to the identity of the two, but I was unable to find a positively Fabrician specimen of *Pepsis johannis*, as Fabricius called it, in any of the European collections, so the relation of the two cannot be considered as proven.

Chlorion (**Prononyx**) **atratum** (Lep.). I have now seen specimens of this species from Oregon and Washington, thus giving it a continuous distribution across the northern border states.

Chlorion (**Prononyx**) **thomæ** (Fab.). In the Fabrician collection at Kiel are four specimens, all males, under the label *thomæ*; also a large female of the same species under the label *crucis*. Evidently Fabricius did not recognize their identity. *Thomaæ*, having been described first, is the name which holds. In Paris is a specimen bearing the Fabrician label "P. crucis p in Guadeloupe fab" but it is *Chlorion* (*Ammobia*) *ichneumoneum aurifluum* Perty.

Chlorion (**Prononyx**) **pubidorsum** (Costa). In the Achille Costa collection at the University of Naples is undoubtedly the type of this species, published in 1862, labelled "M Zool No 7882"; "Enodia ♂ 11.76 pubidorsum A Cos Biogian." This is the species hitherto generally called *Chlorion* (*Prononyx*) *bifoveolatum* (Tasch.), published in 1869. The identity of these species (I have also seen Taschenberg's type) is certain, but I have not been able to learn the meaning of the word "Biogian" on the label. I have named and sent out many specimens of this species during the last twenty-five years labelled *bifoveolatum* Tasch. which should be corrected to *pubidorsum* A. Costa.

An examination of the type of *Chlorion* (*Prononyx*) *excisum* (Kohl) at Vienna confirms the belief I expressed in Proc. U. S. Nat. Mus., xxxi, 417 that this insect is only a variant of *pubidorsum*.

Chlorion (**Prononyx**) **neoxenum** (Kohl). I think that Kohl was correct in his opinion that the specimen from which he described this species bore a wrong locality label and that instead of coming from Vancouver Island was South American. It is the same as my *simillimum* from Argentina. From a study of the type of *Chlorion* (*Prononyx*) *ommissus* (Kohl) I am of the opinion that this will prove to be the male of *neoxenum*.

Chlorion (**Isodontia**) **aztecum** (Sauss.). The type of Cameron's *Isodontia robusta* ♀, in the British Museum is this species, but with an unusually dark costal margin of the wings.

Sphex apicalis Smith, (Hym. Brit. Mus., iv, 262, 1856) has generally been supposed to apply to the species now known as *Chlorion* (*Isodontia*) *harrisi* Fern., the name *apicalis* being preoccupied. Examination of Smith's type, however, shows that it is not this species, but the one known as *Chlorion* (*Isodontia*) *aztecum cinereum* Fern. Had the name *apicalis* not been made use of previously, this discovery would have necessitated a number of changes which fortunately are not needed.

Subgenus **Ammobia** Bilb.

When I proposed the subgenus *Proterosphex* (Proc. U. S. Nat. Mus., xxxi, 65, 1906) I failed to give sufficient consideration to Billberg's paper. Mr. Rohwer has correctly substituted Ammobia Billberg for my Proterosphex.

Chlorion (**Ammobia**) **habenum** Say. The type of *Sphex princeps* Kohl, "Vaterland unbekannt, wahrscheinlich Australien" in the Vienna Museum is unquestionably this species: *princeps* accordingly, is a synonym of *habenum*. I have now seen specimens from Honduras, Guatemala and Mexico in addition to the localities previously listed.

Cameron describes his *Sphex guatemalensis* from both sexes. In the British Museum I could find only two specimens so marked, both females. One of these is *Chlorion habenum* Say while the other is a true example of *guatemalensis* (see below).

Chlorion (**Ammobia**) **opacum** (Dahlb.). One male labelled "Sphex opaca Am. merd." in Dahlbom's writing is in the Dahlbom collection at the University of Lund and is what has been generally called *Chlorion* (*Ammobia*) *flavitarsis iheringii* (Kohl). In consequence, the names of the species and subspecies concerned must be rearranged, *Chlorion flavitarsis iheringii* (Kohl) becoming *Chlorion opacum* (Dahlb.); *Chlorion flavitarsis* Fern. becoming *Chlorion opacum flavitarsis* Fern.; *Chlorion flavitarsis saussurei* Fern. becoming *Chlorion opacum saussurei* Fern. and *Chlorion flavitarsis guatemalensis* (Cam.) becoming *Chlorion opacum guatemalensis* (Cam.).

In the British Museum is a male Chlorion labelled "flavovestita Type Sm." but with no locality or catalogue number. Smith described this species as from India but it is certainly *opacum*. It seems probable that the locality given by Smith is erroneous.

Chlorion (**Ammobia**) **nudum** Fern. I now have records of captures of this species from King William Co., Va., July; and from Jocasse, S. C., August 19; and of its probable female, *Chlorion* (*Ammobia*) *bridwelli* Fern. from "near Alto Pass, Union Co., Ill." and Wesson, Miss., both taken in August, thus considerably extending the known range of these species.

Chlorion (**Ammobia**) **caliginosum** (Erichs.). Five specimens, all females, labelled *erythroptera* Cam. in the Biologia collection at the British Museum, none marked Type, agree with specimens of *caliginosum* Erichs. in the Berlin Museum labelled Type. One of these last is also marked "caliginosa N Brasil" enclosed by a black line and on green paper. I was informed that this is a Klug label. If so, it would seem that Erichson adopted Klug's museum label for his own to publish.

Chlorion (**Ammobia**) **singularis** (Smith). The type of this species; of Cameron's *singularis;* of Costa's *chlorargyrica* and of Kohl's *spiniger* have all been studied and are the same species. Smith's name, being the oldest, must hold for this insect. A male specimen in the Banksian collection at the British Museum, labelled *ichneumonea* is also this species. At Oxford, a female Chlorion bearing the four labels: "Ega Bras"; "singularis Ega Smith"; "I see no difference between this and specimens of S. barbara from Texas in Mus. Smith"; "Coll Smith 1879" does not agree with the London specimen at all well and is likely to prove to be *Chlorion* (*Ammobia*) *brazilianum* (Saussure). *Tinctipennis* Cam. is no more than a variety of this last.

Pepsis fervens Fab. (not Linné). The species so named by Fabricius in his Systema Entomologiæ, is recorded as from "India orientali." There are two specimens placed under this name in the Fabrician collection at Kiel, but being supposedly Asiatic, I did not examine them. In the Paris Museum, however, I found a specimen bearing the Fabrician label "p. fervens p St Domingue fab" and a second, "Museum Paris St Domingue Coll Bosc 1828. Whether this specimen is the same species as those at Kiel I am unable to say, but in any case the one in Paris is what has been known as *Chlorion* (*Ammobia*) *resinipes* Fern. As it is not the Linnean *fervens*, however, *resinipes* still holds as the name of the San Domingo species.

Chlorion (Ammobia) fuliginosum (Dahlb.). In the Berlin Museum are three specimens of this species, two males and a female. One male bears the labels: "Type"; "fuliginosus M Dahlb." and "fuliginosa N Brasil" (and an undecipherable word). This last label is Klug's usual one. The other male has the genitalia mounted on a card, below which are: a blank white label; "fuliginosa" in Dahlbom's writing; and "Type." These two would seem to be Dahlbom's types. The female is marked "Type"; and "Sphex congener Kohl." I suspect that as Kohl described *congener* from females, this is one of his types, sent here to go with the males as *congener* is undoubtedly the female of *fuliginosum*. At Lund is a specimen marked "73"; "Tranquebar"; and "Sphex fuliginosa Berl. Mus. Ent. Er. e Brasil." This insect does not seem to be of the same species as the others.

Chlorion (Ammobia) latro (Erichs.). At Berlin are two specimens, male and female. The latter has only one label, reading "Type": the male has four: "Type"; "latro Er. Br. Guy." followed by a word something like "Whonat"; "4701" and "Sphex roratus Kohl ♀." The identity of the two species had evidently been determined when this last label was prepared, though in Kohl's paper (Ann. k. k. naturh. Hofmus., v, 219, 1890) he only suggests the possibility that they may be the same. I have seen the types of both species and place *roratus* in the synonomy.

Chlorion (Ammobia) melanopum (Dahl.). A specimen of this species at the Berlin Museum carries three labels: "melanopa Dahl."; "Type"; and "Sphex *ruficauda* Taschenberg." It is probably Dahlbom's type as I found no specimens of this species at Lund. The type of *Sphex proxima* Smith in the British Museum and that of *Sphex ruficauda* Tasch. at Halle are both this species, thus proving Kohl's belief as to their identity to be correct.

Chlorion (Ammobia) dubitatum (Cress.). The types of *Sphex micans* Tasch., described from five females are of the same species as Cresson's *dubitata*. I have seen the types of both. It is quite likely that Smith's *dorsalis* is also the same though I found no specimens in the British Museum bearing his label. Four at Oxford, named in his writing, are this species, though. Smith considered his specimens to be Lepe-

letier's *dorsalis* which may be correct, but this type, being in the Spinola collection, which I was unable to locate, makes it impossible to prove their identity at present. Until this point has been settled, therefore, this insect must be known by Cresson's name.

Genus **Sphex** L. (**Ammophila** of many authors).

Reasons for the use of the name *Sphex* instead of *Ammophila* have already been presented elsewhere. I may be permitted to repeat, however, the statement that the original species of the genus, published by Linné in the tenth edition of the Systema Naturæ, by rule must furnish the genotype. By 1805, though, all of these had been removed to other genera while other species, many of them really belonging elsewhere, had been added to *Sphex* by a number of describers. It may be well, therefore, to call attention here to the point that Fabricius seems to have realized this situation, for in 1804, in his Systema Piezatorum, he groups the different species in the genera *Pelopaeus*, *Sphex*, *Pepsis* and *Chlorion*. In *Sphex* he places four species: *sabulosa* L., the first one named by Linné; and three of his own. All of these belong in *Sphex* (s. str.) as used here. Under *sabulosa* he correctly gives as a synonym *Ammophila vulgaris* Kirby, and under *Pepsis arenaria* he gives as a synonym *Ammophila hirsuta* Kirby, now a *Podalonia*. This synonomy evidences that, at least as far as the species he (Fabricius) included in this book are concerned, he did not recognize *Ammophila* as a valid genus, and his restriction of *Sphex* to species which are still congeneric and one of which was Linné's *Sphex* No. 1, would indicate that he was trying to purify an assemblage of species belonging in numerous genera and select as members of *Sphex* those species congeneric with Linné's "chef de file."

In the following synonomy the names of species of which I have studied the types are preceded by a *.

Sphex abbreviatus (Fab.). In the collection at Kiel under "34 Pelopaeus"; "8 abbreviatus" are two male specimens. either would fit the description fairly well but they are different species. The first is the same as a specimen in the Berlin Museum marked "Brasilien"; "4851"; "melanaria N," and one at Lund marked "Brasilia Berl. mus"; "melanaria Kl";

"Am. binodis Fabr. certe, see Mus. Havn. p. 8, Am. melanaria K M. 13. Dlbm H. E. 15." Both of these last are males and one or both were undoubtedly the insect or insects used by Dahlbom in preparing his description of *Ammophila melanaria*. In view of the fact that Dahlbom gives "Kl. Mus. Berol" in connection with his description it would seem that type value should be given to the Berlin specimen rather than to the one at Lund.

With the original description of *abbreviatus* fairly applicable to either species at Kiel, and with the first one certainly the same as *melanaria*, I have decided to consider the Fabrician specimen standing second after the label as Fabricius' type, thus avoiding the synonomy which would otherwise be involved.

Many writers have identified and listed *abbreviatus* from North America. Thus far I have failed to find in any of these a true example of this species and doubt if it occurs any great distance, if at all, northward into Central America. The insect usually marked by this name, captured in the United States, is **Sphex aureonotatus* (Cam.). Sometimes it has been identified as *Sphex* or *Ammophila gracilis* Lep., but *gracilis* appears to have some ferruginous on its abdomen (Rohwer—in lit.—agrees with this) to judge from the description.

***Sphex binodis** Fab. This species has not been recognized from the description. In the Paris Museum I found an insect bearing the three labels: "S. binodis p. Cajanne fab" in Fabricius' writing; "Museum Paris Cayenne Coll Bose 1828"; "abbreviata det Kohl ♂." As Fabricius described the species from "Cajenne Mus. Dom. Bosc" there would seem to be little doubt that this specimen is the type. The last label probably means that Kohl saw this insect and considered it the same as *Sphex abbreviatus*, and that as it is a female, he regarded it as of the other sex of *abbreviatus*. This is probably correct.

***Sphex arvensis** (Dahlb.) The type is in the Dahlbom collection at Lund, marked: "Ammoph. arvensis Berl. mus. eul (col?) Er. ♂ ♀ Pensylv. Zimrmn." It is a male. Dahlbom writes after his description of this species: "Ammophila id. Klug. Mus. Berolin. Exemplar unicum e Pensylvania Americae borealis amice communicavit Cel. Dr. Zimmermann."

The one in the Berlin Museum referred to is probably the one marked: "N. Amerika"; "inepta Cr. det. Kohl"; "arvensis

N Am. sept."; this last in Klug's handwriting. As the specimen at Lund has a petiolated third cubital cell in each fore wing it is evidently Dahlbom's type which he placed under *Miscus* because of this venation. I have examined nearly two thousand insects of this species from all parts of North America but have found no other case of a petiolated third cubital cell, so consider the type as having an abnormal venation. The Berlin specimen has the normal venation. This view is also supported by the fact that in the right fore wing of the type only the front third (about) of the first transverse cubital vein is present. I find, though rarely, an example of some species of *Sphex* in which the third cubital cell is almost petiolated, but one or two, only, among hundreds of the specimens examined. I am not prepared to attack the validity of *Miscus* as an Old World genus, but am positive that it is not present in North America and that any specimen of Sphex having a petiolated third cubital cell is only an individual deviation from the normal.

As synonyms of *Sphex arvensis* I place **Ammophila urnaria* Dahlb., of which at Lund are two specimens, one from "S. Carolina Zimrmn"; the other marked "urnaria Kl. Mus. Berl." As Dahlbom gives South Carolina and Pennsylvania for habitat and states that he received specimens from Zimmermann the former is undoubtedly one of those from which his description was made. I could not find any specimens at Berlin which I could feel certain had been seen by Dahlbom. As synonyms I also place **Ammophila vulgaris* Cress.; **Ammophila mediata* Cress, and **Ammophila inepta* Cress.

This species is the most widely distributed of any American *Sphex*. I have seen an example from Fort McLeod, about 55° north latitude; from Guatemala, and from practically every State and from Mexico. As might be expected, it varies greatly and Cresson's descriptions are of variations, with specimens he identified as *urnaria* the typical *arvensis*.

The chief varying characters in this species are the degree of pilosity and its color; the area covered by ferruginous; and size. *Vulgaris* is a very pilose, white haired form; *mediata* averages slightly larger and the hairs on the head (and sometimes on the prothorax) are brown, while *inepta*, found more frequently in the southern states, is liable to be more slender in proportion to its length and rather sparsely pilose. The

amount of surface which is ferruginous seems to be determined by the humidity of the locality where the insect occurs, a relation already discussed in connection with *Sphex procerus* (Ann. Ent. Soc. Am., xix, 88, 1926). Size seems to be extremely variable in the same species and it has been suggested that this may be due to different amounts of food supply stored for the young to feed upon, either from difficulty in finding enough, or possibly from haste because of a necessity for immediate egg deposition. Examples which might almost be termed dwarfs are certainly often met with in *Sphex* and *Podalonia*, while others, almost gigantic in comparison, also occur.

Aside from the differences just named, and between the limits of which all intermediate conditions occur, I have been unable to find any stable morphological characters by which the above named species can be separated.

***Sphex procerus** (Dahlb.). This species, like the last, has a very wide distribution and is very variable. Its synonyms are: **Ammophila gryphus* Sm., ♀ ♂; **A. saeva* Sm., ♀; **A. conditor* Sm. ♀; **A. macra* Cress., ♂; *A. barbata* Sm., (no type found, either in the British Museum or at Oxford); **A. ceres* Cam. ♂; **A. championi* Cam., ♀; and **A. striolata* Cam., ♀.

The range in size of this species is enormous and the amount of ferruginous on the abdomen also varies greatly. In *saevus* Sm. from California and *striolatus* from Ventanas, Mex. the black is greatly reduced, giving the abdomen an almost entirely ferruginous appearance above. When one female is eighteen millimeters long and another is twice that length, and when in some cases the abdomen shows only slight traces of ferruginous while in others it is nearly all of that color it seems almost impossible that only one species is involved. Yet structurally no fixed differences seem to occur, and reluctantly I have come to believe that all the different names listed above belong to the same species.

***Sphex breviceps** (Sm.), ♀. I am unable to separate **Ammophila pruinosa* Cress. and **A. varipes* Cress. from Smith's *breviceps*. **A. comanche* Cam. is also a synonym. The species is a variable one, in some regions being only slightly pubescent, but densely clothed with erect hairs, while in others the pubescence is very complete and the erect hairs rather few. All intergrades between these extremes occur and the

amount and distribution of the ferruginous is also very variable. No fixed morphological differences have thus far been found, however, though a typical *pruinosa* looks quite different from a typical *breviceps*.

***Sphex placidus** (Sm.). This species, described from California, proves to be the same as the later published *Ammophila pictipennis* Walsh, **A. extremitata* Cress., **A. anomala* Tasch. and *Sphex nigropilosus* Rohwer. I have not myself seen Rohwer's type but have examined specimens from the same locality, loaned me by the U. S. National Museum and do not find two teeth on any of the claws. Others, who have examined the type, also fail to find a second claw and are of the opinion that *longispinus* might well be placed as identical with *pictipennis*.

Western and southern specimens of this species are larger, stouter and more coarsely marked than northern and eastern ones, which probably explains why *placidus* has not heretofore been recognized.

Sphex aberti (Hald.). The type has been lost, but the insect is so distinctive in its typical condition there can be little doubt as to its identity. **Ammophila yarrowi* Cress. and **A. montezuma* Cam. are synonyms.

This is such a variable species in different parts of its range that only a long series of intergrading examples has kept me from describing several new species from the lot!

***Sphex politus** (Cress.), ♀. The male of this tiny species has since been described by Kohl as **Ammophila nearctica*.

***Sphex ferruginosus** (Cress.). This striking species is in all probability the female of Cresson's *collaris* ♂, though proof of this is lacking. Nor can I separate it from *Coloptera wrightii* Cress. structurally, except by the size. The original basis for the establishment of *Coloptera* was the presence of two (first and second) cubital cells only, caused by the obliteration of the second cubital cross vein, or by the fusion of the second and third cross veins. This distinction now seems to be of little value owing to abnormalities of venation which are quite common in this group, but others, such as the form of the collar and its transverse rugosity, etc., have led Kohl to include several species in an "Artengruppe" with the name *Coloptera*. As *wrightii* and *ferruginosus* have these characters in common

and differ only in size (and with intermediates, here) I find no reason for separating them. The type itself of *wrightii* has two cubital cells in the left fore wing and three in the other, the third, however, lacking the central third of the third transverse cubital vein! This subject will be discussed further, elsewhere.

Sphex harti new name. The species described by Hart as *Ammophila argentata* had not previously been named but its transfer to the genus *Sphex* as *Sphex argentatus* is not possible as Fabricius described a *Sphex argentatus* in 1787. I therefore replace this preoccupied name by the specific name *harti* in recognition of the original describer of the species.

Genus **Chalybion** Dahlb.

Chalybion cyaneum (Fab.). The discussion above, on *Chlorion coeruleum* should have made it plain that the name *coeruleum* cannot be used, either for the digger wasp, *Chlorion*, or the common mud dauber, *Chalybion*, as has even recently been done. The first name hitherto recognized as available for the mud dauber was given by Dahlbom, but under his description he gives references to Linnè, Systema Naturæ, Ed. 12 and Amoen, Acad., 6; DeGeer, Mem. 3; Fabr., Ent. Syst., 2, 201, and Syst. Piez., 211. These follow his words: "*Sphex cyanea*," but the first three when checked (by Dalla Torre's Catalogus) prove to be under the name *coerulea!* The Fabrician references are to the name *cyanea* and as the types at Kiel under the name and number referred to by Dahlbom are the same species as those so named in the Dahlbom collection we can safely attribute the name *cyanea* to Fabricius rather than to Dahlbom.

ON "DYAR'S RULE" AND ITS APPLICATION TO SAWFLY LARVAE.*

RAYMOND L. TAYLOR,
College of William and Mary.

INTRODUCTION.

Forty years ago Dyar (1890) sought to establish a criterion by which it would be possible to determine, by simple mathematics, the correctness or incorrectness of the number of instars observed. This was based upon the apparent close agreement between calculated and actual widths of the heads of all larval instars of 28 species of caterpillars, which had from four to ten stadia. In most cases, the calculated and observed widths were either identical or within 0.1 mm., though, apparently, a discrepancy of 0.2 mm. was not considered significant. In six cases of greater deviation in various instars among these species, the explanation offered was "abnormal development"—either dwarfing, because the larva was "unhealthy" and failed to cast its skin, etc., or unusual growth. In five other cases, probable incorrect measurements were admitted. From these data, Dyar found that the size of the larval head is (relatively) static during a stadium and that " . . . the widths of the head of a larva in its successive stages follow a regular geometrical progression . . ." (It was suggested that the width of the larval head is the most convenient measurement to take.)

It was not stated that this principle might apply generally; indeed, since the title restricts the article to "lepidopterous larvæ" and the species dealt with are all caterpillars, it might be construed that this rule may apply only to Lepidoptera. The impression that this is true is shared by some entomologists. Dyar's Rule has become better known than similar ratios[1] and

*The material for this paper was gathered while the writer was in the employ of the Maine Forest Service and acknowledgment is herewith made. The writer is indebted to Dr. F. L. Campbell for valuable suggestions in the preparation of the paper.

[1]Dyar was not the first to attempt the formulation of growth rules. In a recent paper, Calvert (1929) includes a comprehensive historical treatment of the work done on growth rates in Arthropoda and on the attempts to establish mathematical constants for the change in dimensions between instars.

has been incorporated in several entomological texts, *e.g.*, Comstock, Imms, where it is not definitely stated how extensively or how reliably it may hold. While this rule has been utilized in determining, or in corroborating, the number of larval instars in a number of instances, these have been chiefly species of Lepidoptera. Applications of Dyar's Rule in groups other than this order apparently have been rare. Two instances have been noted: Wu (1923) found a ratio of increase of approximately .95 for 22 "larval" instars of the stone-fly, *Nemoura* (from Calvert), and Calvert (1929, p. 253, footnote 10) utilized Horsfall's (1929) data on head capsule widths in successive instars of the grapevine sawfly, *Erythraspides pygmaeus* (Say).[2]

APPLICATIONS OF DYAR'S RULE TO SAWFLY LARVÆ.

The purpose of this paper is to present the data and conclusions of two tests of the application of Dyar's Rule to sawfly larvæ. One test is concerned with one hundred head measurements of each of the seven instars of the birch leaf-mining sawfly, *Phyllotoma nemorata* (Fallen), and the analysis of these with respect to range, modes, means, calculated means, Probable Error, and the like, per instar. The other test is concerned with series of head measurements (based upon an unknown number of individuals per instar but probably very few or single in each case) of 46 species of sawfly larvæ described by Dyar and quite comparable to the sort of data upon which Dyar's criterion was based.

In the summer of 1929, in the course of a biological study of the birch leaf-mining sawfly, a series of head capsules were measured at daily intervals from the time of hatching until the cocoon, or hibernaculum, had been formed by the prepupa. It was noted that the feeding stages of this sawfly fell into definite groups according to their head widths, and that these groups exhibited a common ratio of increase, *i.e.*, the head widths formed a geometrically progressive series—except the non-feeding, last larval instar or prepupa, the head capsule of

[2]Calvert calculated the successive growth-factors as follows: 1.67, 1.50, 1.31, 1.21, 1.16, in this case (using the reciprocals of Dyar's ratios which, in the same order, would be .60, .67, .77, .82, .86). The degree of variation here is very considerable and it is evident that Dyar's Rule does not hold when applied to Horsfall's measurements of this sawfly.

which does not increase in size. These groups, moreover, corresponded with the apparent total number of cast skins per individual larva obtained from the mines. So consistent were these measurements, that Dyar's principle was accepted as one of the bases for deciding upon the number of instars in a paper recently published (Taylor 1930).

Later, to test the application of Dyar's Rule to this sawfly still more extensively, one hundred individuals of each of the seven[3] instars were measured, with the result that the conclusion derived from the preliminary measurements is sound, apparently, provided only the modes and means are considered. These data are presented in Table I and are analyzed in Table II. All measurements were made of the dorsal aspect of the head capsule at its greatest width[4] with a micrometer disc—ruled into five divisions of ten fine units each—in one (9x) ocular. The objective was 2.3x, hence, in reducing the micrometer fine unit readings to mm., the divisor was 23 and each fine unit equalled 0.04348 mm. Readings in each case were made to

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[3]If the non-feeding, "ultimate stage" of Dyar (1896), or prepupa, be included, a number of sawflies have seven instars in females and one less feeding instar in males (Middleton, 1923; Severin, 1920; Horsfall, 1929). Dyar's data indicate that this is apparently likewise the case with *Hylotoma mcleayi* Leach and others, though this was not apparent to him since he interpreted his data as referring to the same number of instars for each sex, with apparent marked sexual differences in the size of the head capsules. Of this species, he says (1895b, p. 210):

"In the last moult there is no increase in the size of the head, but the larvæ feed in the last stage. [This feeding is not true of sawfly larvæ in general.] The male larvæ are smaller than the female, and their heads do not enlarge at the moult before the last, so they possess the anomalous character of having three stages without any growth of the head. I have never observed anything of this kind in the Lepidoptera, perhaps owing to their very different manner of moulting. In the saw-flies the old head is split at each moult, as in the Lepidoptera at pupation only, and the new one has to grow after the moulting instead of largely before it, as in the Lepidoptera."

Here is a possible explanation of why Dyar did not attempt—or, more strictly, to publish any such attempt—to apply his own rule to the large series of sawfly larvæ he described. The following quotation from the description of the first stage of *Strongylogaster pinguis* (1895a, p. 311): ". . .width .35 mm. (probably an error; .5 is the calculated width)" indicates that Dyar, at least in this case, did attempt to apply his own rule to sawfly larvæ.

All *Phyllotoma nemorata* larvæ are female-producing so far as is known—no one has obtained a male and a count of 3,000 adults made over the entire emergence period for this specific purpose revealed no males—and all larvæ followed through had seven larval stages including the prepupa.

[4]Considerable variation in the *shape* of the head, which ranged from nearly circular to broadly crescentic or rectanguloid, appeared to be the primary factor in the degree of size variability found. (A perusal of Yuasa's (1922) paper inspires the impression that the shape of the entire head of Tenthredinoid larvæ may be considered a stable character, but, either this impression is incorrect or this instance is atypical).

estimated tenths of the fine units so that each successive point of the scale in Table I represents a head width greater by 0.004348 mm. The larvæ measured were mixed originally and final classifications to instar were not made until, *after* measurement, it was indicated that these classifications could be made safely, at least in the later stages. In the extreme cases, where the measurement was such that there was a question as to which stadium the larva belonged, it was possible to decide with the aid of other characters, *e.g.*, the general body size, the color of the head, which is pale immediately following ecdysis, any abnormality apparent in the shape of the head (See footnote 4), etc.

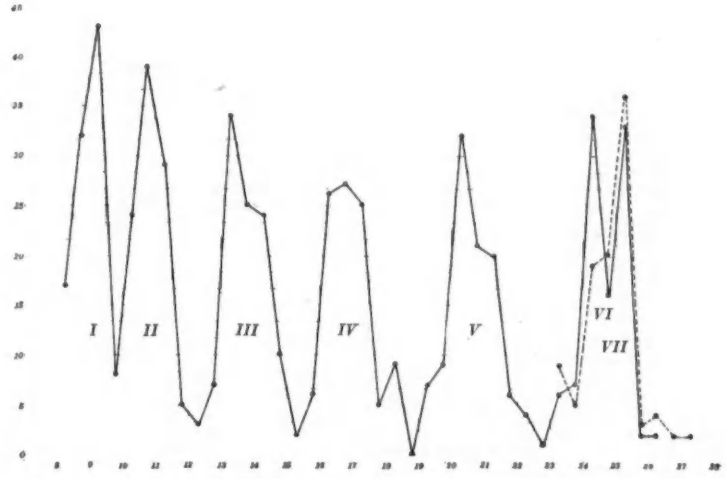

FIG. 1. A graph to show the distribution of *Phyllotoma nemorata* larvæ, 100 for each instar, according to their head widths. It may be noted that the modal head width characterizes the instar in each case, that the extremes of the range for each instar tend to merge, and that the head capsule of the seventh instar—shown by dotted line—does not increase in width.

(The figures of the horizontal axis are in micrometer fine units and each point, as plotted, represents the frequency for each successive five-tenths of the micrometer fine units, *i. e.*, the frequencies of Table I thus are grouped by fives. Each successive head width is greater by approximately 0.02 mm.).

TABLE I.

The Distribution of *Phyllotoma nemorata* Larvæ According to Their Head Widths.

NOTE: Figures represent the number of individuals per head width. Units of the scale are *not* in mm., but in tenths of micrometer fine units as explained above. Each mean is marked.

Instar I	Instar II	Instar III	Instar IV	Instar V	Instar VI	Prepupa*
8.0– 4	10.0– 5	12.5– 2	15.2– 1	19.0– 4	23.0– 3	3
8.1– 6	10.1– 7	12.6– 2	15.3– 1	19.1– 0	23.1– 1	1
8.2– 3	10.2– 3	12.7– 2	15.4– 0	19.2– 1	23.2– 1	3
8.3– 1	10.3– 4	12.8– 1	15.5– 0	19.3– 0	23.3– 0	1
8.4– 3	10.4– 5	12.9– 0	15.6– 0	19.4– 2	23.4– 1	1
8.5– 4	10.5– 5	13.0–12	15.7– 3	19.5– 3	23.5– 2	2
8.6– 5	10.6– 6	13.1– 9	15.8– 1	19.6– 2	23.6– 0	1
8.7– 4	10.7– 8	13.2– 2	15.9– 2	19.7– 0	23.7– 0	0
8.8–10	**10.8–13**	13.3– 5	16.0– 7	19.8– 2	23.8– 1	2
8.9– 9	10.9– 7	13.4– 6	16.1– 7	19.9– 2	23.9– 4	0
9.0–30	11.0–16	13.5– 2	16.2– 3	20.0–13	24.0–28	15
9.1– 5	11.1– 5	13.6– 1	16.3– 5	20.1– 8	24.1– 2	0
9.2– 3	11.2– 3	**13.7– 3**	16.4– 4	20.2– 7	24.2– 1	4
9.3– 4	11.3– 0	13.8– 8	16.5– 5	20.3– 2	24.3– 1	0
9.4– 1	11.4– 5	13.9–11	16.6– 5	20.4– 2	24.4– 2	0
9.5– 2	11.5– 3	14.0–12	16.7– 3	**20.5– 8**	**24.5– 4**	11
9.6– 2	11.6– 2	14.1– 3	**16.8–10**	20.6– 0	24.6– 0	3
9.7– 1	11.7– 0	14.2– 4	16.9– 4	20.7– 2	**24.7– 3**	**2**
9.8– 2	11.8– 0	14.3– 3	17.0–15	20.8– 7	24.8– 5	3
9.9– 1	11.9– 0	14.4– 2	17.1– 5	20.9– 4	24.9– 4	1
	12.0– 2	14.5– 3	17.2– 1	21.0–14	25.0–28	26
	12.1– 0	14.6– 0	17.3– 1	21.1– 3	25.1– 2	2
	12.2– 1	14.7– 5	17.4– 3	21.2– 0	25.2– 2	5
	12.3– 0	14.8– 1	17.5– 0	21.3– 3	25.3– 1	3
	12.4– 0	14.9– 1	17.6– 0	21.4– 0	25.4– 0	0
		15.0– 0	17.7– 2	21.5– 0	25.5– 0	2
		15.1– 0	17.8– 1	21.6– 3	25.6– 1	0
			17.9– 2	21.7– 0	25.7– 0	1
			18.0– 6	21.8– 1	25.8– 1	0
			18.1– 2	21.9– 2	25.9– 0	0
			18.2– 1	22.0– 3	26.0– 2	4
			18.3– 0	22.1– 0	26.1– 0	0
			18.4– 0	22.2– 0	26.2– 0	0
			18.5– 0	22.3– 0	26.3– 0	0
			18.6– 0	22.4– 1	26.4– 0	0
			18.7– 0	22.5– 1	26.5– 0	1
			18.8– 0	22.6– 0	26.6– 0	1
			18.9– 0	22.7– 0	26.7– 0	0
				22.8– 0	26.8– 0	0
				22.9– 0	26.9– 0	0
					27.0– 0	2

*The head does not increase in size at the molt preceding the prepupal stage.

TABLE II.

An Analysis of the Head Measurements of the Larvæ of *Phyllotoma nemorata* per Instar.

NOTE: All calculations were made in the micrometer units for convenience, but conversions into millimeters were made in these final figures; the data in this table are in millimeters only.

All larvæ, except 89 of the prepupæ (from Hartland, Me.), were taken from an identical area, *viz.*, a small tract near the Entomological Laboratory at Bar Harbor, Me.

	I	II	III	IV	V	VI	VII
Size range	0.348 to 0.430	0.435 to 0.530	0.544 to 0.648	0.661 to 0.791	0.826 to 0.978	1.000 to 1.130	1.000 to 1.174
Modes	0.391, 0.383	0.479, 0.470	0.609, 0.565	0.739, 0.730	0.913, 0.870	1.087, 1.043,	1.087, 1.043,
Mean	0.385	0.469	0.594	0.728	0.892	1.064	1.072
Calculated Mean[5]	0.385	0.472*	0.578*	0.709*	0.868*	1.064	1.304
Difference	0.000	0.003	0.016	0.019	0.024	0.000	0.232
Probable Error of Mean[6]	±0.0012	±0.0013	±0.0017	±0.0020	±0.0022	±0.0019	±0.0024
Standard Deviation[7]	0.0183	0.0201	0.0253	0.0289	0.0326	0.0278	0.0358
Coefficient of Variation[8]	4.74	4.28	4.26	3.97	3.65	2.61	3.34

[5]In the determination of the calculated mean, the ratio of increase used was an *average*, which was obtained from the means of each instar as follows:

$$\frac{mI}{mII} + \frac{mII}{mIII} + \frac{mIII}{mIV} + \frac{mIV}{mV} + \frac{mV}{mVI} = \frac{.821 + .789 + .815 + .816 + .838}{5} = .816$$

n

Where the calculated mean is followed by an asterisk, it represents the average of *two* calculations, *i. e.*, one made by multiplying the calculated mean of each instar by .816 successively, starting with the known mean of VI for V, etc. to I; the other by dividing the calculated mean of each instar by .816 successively, starting with the known mean of I for II, etc. to VII. Thus the only actual (averaged) widths employed were those of I and VI. (In this case, the calculated means obtained by these two processes were virtually identical.)

[6]The Gaussian formula was used: $\text{P. E.} = \pm 0.6745 \times \frac{\text{Stan. Dev.}}{\sqrt{n}}$

[7]The formula used was:

$$\text{Stan. Dev.} = \sqrt{\frac{e_1^2 + e_2^2 + e_3^2 + \cdots e_n^2}{n}}$$

where e_1, e_2, e_3, etc. are the deviations of the successive counts from the mean and n denotes the number of counts made.

[8]The Coefficient of Variation $= \frac{\text{Stan. Dev.} \times 100}{\text{Mean}}$

The result is an abstract number expressing the variability in *per cent* of the Mean.

The conclusions derived from Tables I and II are as follows:

1. The first six instars of *Phyllotoma nemorata* may be grouped by the widths of their head capsules provided only the "normal" or "average" widths (means or modes) are considered: An instar can be characterized by the average width of the head capsule.

2. A few random measurements, however, not only would be unreliable but might mislead since, as may be noted, the range of the head size per instar is considerable: An instar cannot be characterized by the width of the head capsule of single, or of a few, individuals with reliability.

3. The seventh instar, or prepupa, has a head capsule virtually indentical[9] in size with that of the sixth: Dyar's Rule, when applied to sawfly larvæ, must be qualified in this respect.

4. The modes are reasonably pronounced. (A tendency toward bimodality may be noted in Table I but this is not believed to be significant. It is not improbable that the difficulty of estimating to tenths of the fine units of the micrometer scale resulted in a tendency to overload certain whole numbers such as 20.0, 21.0, 24.0, and 25.0. The double modes so formed are close to the mean in each case. In Fig. 1 this artificiality is discounted largely by plotting the frequencies by halves of the fine units.)

5. The means of the first six instars form a definite geometric progression and the agreement of these with the calculated means is so close that it is evident that Dyar's Rule, when qualified as described above, holds for this species. (Additionally, it may be noted that the Probable Error is low throughout.)

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[9]Apparently it is generally true of sawfly larvæ that the head capsule of the prepupa does not increase in size, or at least not proportionately, over that of the preceding instar. In this species, the head of the prepupa retains the characteristic pale color in marked contrast with the light to dark brown of the heads of the feeding instars. The head of this stage, also, approximates the vertical in position in contrast with the nearly horizontal head of the earlier instars of this leaf-mining species.

(Marlatt (1890), who was one of the first to note the considerable differences between the larvæ of the penultimate and ultimate stages, believes the molt preceding the prepupal one to be "supplemental" and—since, in general, it just precedes the inert, over-wintering state—that it is " . . . analogous to the one before pupation proper in insects, which in Tenthredinidæ is commonly undergone a few days only before the emergence of the mature insect.")

6. The Coefficient of Variation, as applied in this case, indicates that all the instars are rather similar in their degree of variability.

No other comparable series of measurements per instar of other sawfly larvæ was made, nor were similar data available in the literature. It was decided, however, to test the application of Dyar's Rule with certain head measurements of sawfly larvæ by Dyar (1893) (1894) (1895a) (1895b) (1896) (1897) (1898a) (1898b) (1900). With the possible exception of the instance noted in footnote 3, Dyar did not apply his own principle to these measurements, which were given in connection with the descriptions of the larvæ. These data (Table III) are treated by the writer in the same superficial manner as Dyar treated measurements of a series of caterpillars in seeking to establish his criterion. The data of other authors could be utilized similarly but have been omitted, primarily because the number of individuals measured per instar are usually either not given or are too few to yield entirely dependable results. (Dyar's data, though similar in this respect, are used because they are comparable to his data from which the rule was derived.)

Despite the superficial manner of using a ratio of increase based upon a single division and dealing with measurements based upon few or single individuals per instar—following Dyar in this respect—it, nevertheless, may be seen that, in general, as close an agreement between these actual and calculated measurements has been obtained for sawfly larvæ as Dyar found with a smaller series of lepidopterous larvæ.

TABLE III.

The Application of Dyar's Rule to Some Sawfly Larvæ Described by Him.

NOTES: The following genera have different larval habits which are indicated as follows: G=gall-formers, M=leaf-miners, F=free feeders.

The dates following the authors of the specific names indicate the appropriate references among Dyar's papers.

Where Dyar has given the last stage — the "ultimate" or prepupal one— it has been excluded from consideration, since the head width does not change. See the foregoing text and footnote 9.

All measurements are in millimeters.

For explanation of the reference marks see page 462.

Species[10]		Type of Measurement	Successive Larval Stages[11]							Ratio of Increase[12]
Hemichroa americana Prov. 1893	F	act.	.30	.40	.55	.75	1.00	1.40		
		calc.	.26	.36	.51	.71	1.00			.714
Craesus latitarsus Nort. 1893	F	act.	.40	.55	.75	1.05	1.60	2.20		
		calc.	.44	.61	.84	1.16	1.60			.727
Fenusa varipes St. F. 1893	M	act.	.25	.30	.40	.55	.75			
		calc.	.21	.29	.40	.55				.733
Monostegia quercus-coccineæ Dyar 1894	F	act.	.25	.40	.55	.80	1.10			
		calc.	.31	.42	.58	.80				.727
M. quercus-albæ Nort. 1894	F	act.	.25	.35	.50	.70				
		calc.	.26	.36	.50					.714
Nematus coryli Cress. 1894	F	act.	.45	.65	.90	1.25	1.80			
		calc.	.42	.60	.87	1.25				.694
N. salicis-odoratus Dyar 1894	F	act.	.30	.50	.70	1.00	1.40			
		calc.	.36	.51	.71	1.00				.714
N. similaris Nort. 1895a	F	act.	.40	†	.60	†	.90	1.20	1.50	
		calc.	.40	.50	.62	.77	.96	1.20		.800
N. mendicus Walsh 1895a	F	act.	.30	†	.55	†	.90	1.15		
		calc.	.34	.43	.55	.70	.90			.782
N. pingui-dorsum Dyar 1895a	F	act.	1.00	1.30	1.75					
		calc.	.97	1.30						.743
N. dorsi-vittatus Cress. 1895a	F	act.	.65	1.00	1.40					
		calc.	.71	1.00						.714

TABLE III—Continued.

Species[10]		Type of Measurement	Successive Larval Stages[11]								Ratio of Increase[12]
N. ventralis Say 1895a	F	act.	.55	.75	1.00	1.40					
		calc.	.51	.71	1.00						.714
N. corylus Cress. 1895a	F	act.	.70	1.00	1.40						
		calc.	.71	1.00							.714
N. thoracicus Harrington 1895a	F	act.	.25	.33	.50	.70	1.00	1.40	2.00		
		calc.	.24	.34	.48	.69	.98	1.40			.700
Strongylogaster pinguis Nort. 1895a	F	act.	.35	†	.60	1.10	1.40	2.00			
		calc.	.34	.48	.69	.98	1.40				.700
			(See also footnote 3)								
Cladius gregarius Dyar 1895b	F	act.	.30	.40	.65	1.00	1.50				
		calc.	.30	.45	.67	1.00					.667
C. solitaris Dyar 1895b	F	act.	.50	†	.80	1.00					
		calc.	.51	.64	.80						.800
Harpiphorus varianus Nort. 1895b	F	act.	.40	.55	.65	.80	1.10	†	1.50	1.80	
		calc.	.50	.60	.72	.87	1.04	1.25	1.50		.833
Hylotoma mcleayi Leach 1895b	F	act.	1.10	1.40	1.75	2.20					
		calc.	1.11	1.40	1.75						.795
H. pectoralis Leach 1895b	F	act.	.60	.70	.90	†	1.40	1.80	2.20		
		calc.	.65	.80	.98	1.20	1.47	1.80			.818
Fenusa curtus Nort. 1895b	M	act.	.30	.40	.60	.75	1.00				
		calc.	.32	.42	.56	.75					.750
Harpiphorus maculatus Nort. 1896	F	act.	.28‡	.40	†	.60	.80	1.08‡	1.40‡		.771
		calc.	.29	.38	.49	.64	.83	1.08			
Hylotoma scapularis Klug 1897	F	act.	.80	1.10	1.80	2.50					
		calc.	.94	1.30	1.80						.720
Tenthredo remota MacG. 1897	F	act.	.60	.80			1.40	1.80	2.20		
		calc.	.65	.80	.98	1.20	1.47	1.80			.818
Harpiphorus tarsatus Say 1897	F	act.	.50	.60	.80	1.00	1.20	1.60	2.00	2.50	
		calc.	.53	.66	.82	1.02	1.28	1.60	2.00		.800

TABLE III—Continued.

Species[10]	Type of Measurement	Successive Larval Stages[11]							Ratio of Increase[12]
H. versicolor F									
Nort. 1897	act.	.33	.50	.80	1.10	1.50	2.10		
	calc.	.39	.54	.76	1.07	1.50			.714
Schizocerus M									
prunivorus	act.	.40	†	.60	.75	†	1.15	1.40	
Marlatt 1897	calc.	.43	.52	.63	.77	.94	1.15		.821
Pontania G									
populi	act.	.36	.55	.70	1.00				
Marlatt 1897	calc.	.34	.49	.70					.700
P. terminalis G									
Marlatt 1897	act.	.30	.40	.55	.80				
	calc.	.26	.38	.55					.688
Pteronus F									
populi	act.	.60	.75	1.20	1.60	2.20			
Marlatt 1897	calc.	.61	.84	1.16	1.60				.727
Pachynematus F.									
gregarious	act.	.35		.50	†	.80	1.00		
Marlatt 1897	calc.	.33	.41	.51	.64	.80			.800
Siobla F									
excavata	act.	.35	.53		.90	1.30	1.60	2.10‡	
Nort. 1897	calc.	.41	.54	.71	.93	1.22	1.60		.762
Pontania F									
robusta	act.	.35	.50	†	.70	1.00	1.30		
Marlatt 1897	calc.	.35	.45	.59	.77	1.00			.769
P. pallicornis F									
Nort. 1897	act.	.20	.30	.40	.60	†	1.20		
	calc.	.15	.23	.35	.53	.80			.667**
P. gracilis G									
Marlatt 1897	act.	.50	.70	.92‡					
	calc.	.53	.70						.761
Macrophya F									
externa	act.	.90	†	1.20	1.60	†	2.10	2.50	
Say 1898a	calc.	.87	1.03	1.23	1.47	1.76	2.10		.840
Megaxyela F									
major	act.	.60	.80	†	1.20	†	1.80	2.20	
Cress. 1898a	calc.	.65	.80	.98	1.20	1.47	1.80		.818
Nematus F									
chloreus	act.	.40	.60	.80	1.15	1.50‡			
Nort. 1898b	calc.	.52	.68	.88	1.15				.767
Hemichroa F									
fraternalis	act.	.40	.60	†	.90	1.30	1.70‡		
Nort. 1898b	calc.	.44	.58	.76	.99	1.30			.765

TABLE III—Continued.

Species[10]	Type of Measurement	Successive Larval Stages[11]							Ratio of Increase[12]
Periclista F									
purpuridorsum	act.	.60	1.00	1.40					
Dyar 1898b	calc.	.71	1.00						.714
P. albicollis F									
Nort. 1898b	act.	.70	†	1.10	1.40				
	calc.	.68	.86	1.10					.786
P. media F									
Nort. 1898b	act.	.30	.40	†	.60	.80	1.10	1.40	
	calc.	.33	.42	.53	.68	.86	1.10		.786
Isodyctium F									
subgregarium	act.	.80	1.20	1.80					
Dyar 1898b	calc.	.80	1.20						.667
Atomacera F									
desmodii	act.	.60	.80	1.00					.800
Dyar 1900	calc.	.64	.80						
Pteronus F									
ostryæ	act.	.40	†	.70	†	1.00	1.30	1.60	
Marlatt 1900	calc.	.46	.57	.70	.86	1.06	1.30		.812
Schizocerus M									
zabriskiei	act.	.25	.35	.50	.65	.90			
Ashm. 1900	calc.	.25	.34	.47	.65				.722

‡In cases so marked, two measurements (the extremes of the range) were averaged.

†Inconsistencies are indicated here (not to be confused with a few stages which Dyar stated as missing). These 23 instances represent approximately 12 per cent of the number of comparisons made per instar. The following possibilities exist:

1. Dyar missed the stage and was unaware of it.
2. The measurement was inaccurate.
3. The larva measured was abnormal or exceptional, or simply exhibiting natural variation from an unknown mean.
4. Typically, the Rule does not hold—
   a. With sawflies as a group.
   b. With this particular species.
   c. Except when averages of instar measurements are available.

[10]It has been found convenient to list the species just as given in Dyar's papers, without systematic arrangement, and making no nomenclatorial changes.

[11]These data should not be taken as indicative of the *number of instars* for any species listed since, in a majority of cases, these data are incomplete in this respect, even for feeding instars.

[12]The Dyar ratio of increase is derived by the division of any actual measurement by the one of the stage immediately following it. In this table, the last (greatest) actual measurement is the divisor in every instance but one, which is marked ** and represents a division of the first measurement by the second to obtain this ratio. It has not been considered worth while, in these species, to obtain for comparison, the several ratios possible in each case.

DISCUSSION.

General value of Dyar's Rule.—Dyar's Rule has been discussed more or less critically by Ripley (1923), Peterson and Haeussler (1928), Calvert (1929), and others. Ripley, who used the reciprocal of Dyar's ratio, apparently found it useful in identifying instars of Noctuidæ but commented (pp. 38, 39) on "The inconstancy of Dyar's supposed constant . . ." as shown by the variation of the ratio, or "index of growth," within one generation of a given species (*i.e.*, if all the ratios possible in a series of instars of one species be obtained, these ratios very often are not identical) and also by the usually greater variation of the ratios when based upon comparable instars of different broods of the same species. Ripley points out, in addition, that these variations in general scarcely can be correlated with corresponding instars in different species. He says ". . . The variations in the index of growth for any species are of no uniformity, with the exception of the tendency toward largeness of the first [growth increase] and smallness of the last." Peterson and Haeussler found ratios for *Laspeyresia molesta* ranging from .57 to .61 in four-instar groups and from .63 to .75 in five-instar groups. Calvert (p. 260) questions the value of growth constants in Odonata or in other groups in estimates of the growth rate of different species and individuals. He says:

> "Most of the determinations of rates of growth have had reference to units of time (days, months, weeks, or years), or to stages demarcated by moults. Temperatures, by increasing or decreasing the rate of growth, renders the time units so variable that they are often useless in comparing the growth of different species or individuals. Food or its absence, humidity and, in some cases, temperature affect the number of moults, as has been shown *antea*, so that these latter lose much of their significance as indicating definite points in growth. My colleague, Doctor R. L. King, has therefore suggested the advisability of . . . the plotting of definite fractions of the total growth against definite fractions of the time consumed in making that growth." [as others have done]. [This should give] ". . . a more equal basis of comparison of the growth rates of different species and individuals."

These authors have pointed out the limitations of Dyar's Rule or similar principles in comparative growth studies, specific growth rates, and allied research. They have not completely invalidated Dyar's Rule. The impression has been gained that Dyar's original concept of the use, or value, of this rule was merely that it would aid in the corroboration of, or the calculation of, the number of stadia. Nowhere in his paper

(1890) is it stated that a ratio for any species is invariable regardless of multiple generations, environmental changes, etc., nor does it seem that this, necessarily, is implied. On the other hand, the following statement by Dyar indicates that he appreciated the limitations of his rule:

". . . If two sets of observations show a different number of stages for the same insect but each follows its own progression, we may conclude that this variation is actual; but if either set shows a lack of regular progression that one we must regard with suspicion."

Limited to the one use of checking the number of stadia—in certain groups only—and qualified as it must be to allow for variation of individuals within an instar and for cases where a molt is not followed by an increase in head size, Dyar's Rule still may serve its original purpose and prove useful, especially in the case of leaf-mining larvæ, the molts of which are difficult to detect and the exuviæ of which may sift from the mine, and similar cases.

Value of Dyar's Rule when applied to sawfly larvæ and other groups.—In this paper, the primary concern has been to show that—in so far as it is reliable and may be useful—Dyar's Rule may be applied to sawfly larvæ, in general, as well as to lepidopterous larvæ. From the data presented in Table III, the agreement between calculated and actual head widths of the instars of 46 species of sawflies is at least as close and as consistent as in the 28 species of Lepidoptera upon which the criterion was based. In Table II, the agreement of the mean, and calculated mean, head widths of *Phyllotoma nemorata* is very close indeed. Theoretically, it would seem not illogical that Dyar's Rule might be applied successfully to still other groups of insects (or arthropods) provided a tendency toward similar growth phenomena—a size increase chiefly at the molts and a relatively static condition between ecdyses—is marked.

The danger of basing calculations on too few measurements has been demonstrated in the case of *Phyllotoma nemorata*. Table I shows the extent of individual variation within an instar where the head widths of the first four instars merge at their extremes. It seems not improbable that variation to this extent may occur in other species and that even cases of overlapping may be found. Because of this natural variation, which may be considerable in certain groups or under certain conditions, a head dimension of a single individual thus cannot be taken to typify that of its instar. On the other hand, the

mean dimensions of the head, when a reasonably large series is measured, are shown in Table II to characterize the several instars and thus may be employed in the utilization of Dyar's Rule. In general, it would seem unwise to apply this rule unless the basic data be refined by the employment of averages. It can be added that, in all cases where it is feasible to make direct observations throughout, it probably is not advisable to abandon this practice.

SUMMARY.

Dyar's so-called Rule—a generalization which probably need not be dignified by the term Law—which expresses a ratio of growth increase based upon the head measurements of successive larval instars, is described and the apparent restriction of this principle to Lepidoptera is discussed.

The application of Dyar's Rule to the birch leaf-mining sawfly, *Phyllotoma nemorata*, is presented. One hundred head widths of each of the seven instars of this insect are tabulated and these data, per instar, are analyzed in regard to range, modes, mean, calculated mean, Probable Error, and the like.

The agreement between mean, and calculated mean, head widths is very close; modes in each instar are marked; the range is sufficiently extensive so that the extremes of the first four instars tend to merge. The apparent usual lack of any increase in size in the head capsule of the last larval instar of sawflies is evident in this species. (Some notes on this and other characteristics of the prepupal stage of sawfly larvæ are given, chiefly in footnotes.)

Head measurements (based on an unknown number of individuals but probably very few, or but single, in each case) of instars of 46 species of sawflies described by Dyar are tested with his rule. It is shown that—even in this (Dyar's own) superficial manner—Dyar's generalization is upheld at least as well as by the 28 lepidopterous larvæ upon which the criterion was based.

Recent criticisms of Dyar's ratio in regard to its use as a constant in studies of growth, comparable growth, etc., are cited briefly and the general value of this rule, its limitations, and its original purpose are discussed.

The following conclusions are drawn:

1. With the restriction of its use to the corroboration of the number of instars observed, Dyar's Rule may continue to prove useful in certain groups.

2. In general, this rule holds as well with sawfly larvæ as with lepidopterous larvæ.

3. Theoretically, this principle should hold as well with any insect (or arthropod) provided marked increases in head size occur at the molts and only then.

4. This rule will be more reliable and may be utilized with more confidence if calculated head dimensions be determined from averages (which are based upon a sufficiently large number of measurements) per known instars.

5. Unless qualified as above, Dyar's Rule should not be employed, at least not without reservations.

6. In all cases where possible, it probably is not advisable to abandon direct observations.

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THE BIOLOGY OF BITTACUS STIGMATERUS SAY (MECOPTERA, BITTACUSIDÆ).*

LAUREL RAYMOND SETTY,
Park College, Parkville, Mo.

HISTORICAL ACCOUNT.

The genus *Bittacus* was erected in 1807 by Latreille in *Genera Crustaceorum et Insectorum*, for two European species, *italica* Muller and *tipularia* Linn., both of which had been formerly placed in the genus *Panorpa*. In 1823 the first American species of the new genus was described by Say in the *Western Quarterly Reporter*. This was *Bittacus stigmaterus*, the species to be considered in the present paper.

During the next half century many new species were made known to science. *B. mexicanus* (later found by Hine to be identical with *B. stigmaterus* Say) was described by Klug in *Abhandlugen der Academie der Wissenschaften zu Berlin* in 1836; *B. pilicornis*, *B. punctiger*, and *B. pallidipennis* (later found by Hagen to be synonymous with *B. stigmaterus* Say) were described by Westwood in the *Transactions of the Entomological Society of London* in 1841; *B. occidentis* was described by Walker in *The Catalogue of the British Museum* in 1853; *B. apicalis* Uhler and *B. strigosus* Hagen were made known in Hagen's *Synopsis of the Neuroptera of North America* in 1861: finally, *B. apterus* and *B. chlorostigma* were described in 1871 and 1881 respectively by McLachlan in the *Entomologist's Monthly Magazine*.

Nothing regarding the biology of any of these species was known before the time of Brauer, who may rightly be called the first great student of the genus. In 1863 he gave an admirable account of his observations on the habits and life history of the European species, *B. italicus* (and *B. hageni*). Yet nothing was known of a like nature regarding any of our American species.

In 1895 Felt in his paper entitled *The Scorpion-flies*, treating mainly the genus *Panorpa*, gave the first biological and morphological data known for our American species of *Bittacus*. In this work he described the feeding and egg-laying habits

*Contribution from the Department of Entomology, University of Kansas.

of *B. strigosus* (and *B. pilicornis*), but he states that the larval form remained unknown to him. In the same paper he illustrates several structures of the adult *B. strigosus*, including the fore tarsi and venation of the wings.

The next and only recent work of any kind was that of Hine in 1901. In his monograph of *The North American Species of Mecoptera North of Mexico*, he described and illustrated the male genitalia of all of our eight American species. A brief account of the structure of *B. strigosus* and a statement regarding the flying habits of *B. punctiger* and *B. pilicornis* are given by the same author.

The review of the literature shows how meager our bioliogical knowledge is concerning any member of this genus. In spite of the fact that *B. stigmaterus* was the first American species to have been described, less is known regarding it than any other species. In fact, Hine's study of the wings and male genitalia constitutes our major knowledge of its morphology and actually nothing has been known of its biology.

SYSTEMATIC POSITION OF BITTACUS STIGMATERUS.

Comstock characterizes the Mecoptera as follows: The winged members of this order have four wings; these are usually long, narrow, membranous, and furnished with a considerable number of crossveins; the wings are wanting or vestigial in two genera. The head is prolonged into a deflexed beak, at the end of which chewing mouthparts are situated. The metamorphosis is complete.

PANORPIDÆ AND BITTACUSIDÆ.

The genus *Bittacus* was formerly included in the family Panorpidæ, but later Smith placed it in a separate family called the Bittacusidæ. Certainly the differences between the two groups are great enough to warrant this division. These differences may be outlined as follows:

Panorpidæ.

Structure.—(1) The tarsi are provided with two claws and are not fitted for grasping. (2) The last abdominal segment of the male is greatly enlarged. (3) The wings are spotted with black.

Biology.—(1) The adults sit on the surface of the foliage of plants when at rest. (2) The adults feed on dead or injured insects.

Bittacusidæ.

Structure.—(1) The tarsi are provided with a single claw and are fitted for grasping. (2) The last abdominal segment of the male is not greatly enlarged. (3) The wings are not conspicuously spotted with black.

Biology.—(1) The adults hang suspended by their front legs when at rest. (2) The adults normally feed on living insects which they have captured.

GENUS BITTACUS AND KEY TO THE AMERICAN SPECIES.

Hine gives the following description of the genus: The head is small, and largely occupied by the conspicuous compound eyes. The mandibles are widest at the base, and gradually narrowed distally, the distal end is curved and pointed and preceded by a sharp tooth. The maxillæ are peculiar in the large development of the maxillary palpi in comparison with the outer parts; the labium is short bearing two-jointed palps at its distal end. The legs are longer than the wings, which are ample and in most cases without conspicuous markings.

The same author gives the following key by which our eight American species of Bittacus may be identified:

1. Both sexes wingless ..... **apterus**
   Both sexes with wings 2
2. Hind femora and tibiae thickened, cross veins of wings (except *punctiger*) not margined 3
   Hind femora slender, cross veins of the wings margined with fuscous 6
3. Large dark colored species, pterostigma bright yellow ..... **chlorostigma**
   Smaller species, pterostigma not bright yellow 4
4. Wings at base, and hind femora with black punctate spots ..... **punctiger**
   Wings at apex fuscous ..... **apicalis**
   Wings and hind femora unmarked 5
5. Male appendages not protruding beyond the last segment of the abdomen, rounded at the distal end ..... **occidentis**
   Male appendages protruding beyond the last segment, turned inward at apex ..... **stigmaterus**
6. Antennae with long pile, wings testaceous, with cross veins narrowly margined with fuscous ..... **pilicornis**
   Antennae with short pile, wings pale, with the cross veins broadly margined with fuscous ..... **strigosus**

Bittacus stigmaterus Say is described by Hine as follows: "Anterior wing, 18–21 mm., body, 16–18 mm. Light brown; ocelli surrounded by black, eyes black, rostrum and maxillary palps black, the pile on the antennæ is noticeably longer than in *occidentis*, veins of wings prominent, hind femora thickened, the outer of the two spines at the end of each hind tibia as long as the first tarsal joint. Male appendages, from side view, oblong, superior edge strongly elevated at base, nearly straight to apex, inferior edge very gradually approaching the superior, thus making the apex slightly narrower than the base; length of the appendage about 2 mm."

The popular name "scorpion-flies" has been applied to the members of the genus *Panorpa* because of the enlarged forcep-like claspers of the male. Some writers and teachers of entomology appear to include the members of the genus *Bittacus* under the same term, though the male appendages have no likeness whatever to those of a scorpion. This is, as Dr. Felt has stated, perhaps due to the lack of a more appropriate common name. For non-technical purposes, I would suggest that the members of this genus be called "hanging-flies." Certainly, hanging is a habit peculiar to these insects and hence may rightly be used. The term will be employed throughout the present paper.

DISTRIBUTION.

Species of *Bittacus* occur both in Europe and in America. Some of our species have a wide distribution, but others have never been collected beyond the limits of a single state. Thus *B. strigosus* occurs in nearly all of the eastern half of the United States, extending westward as far as Kansas, while *B. chlorostigma* and *B. apterus* are found only in certain parts of California. *B. stigmaterus* has been collected in the following states: New York, Ohio, Illinois, Maryland, Virginia, Georgia, Missouri, and Kansas. Moreover, within the last state named, it is known to occur in the following counties: Riley, Montgomery, Smith, Rooks, Osborne, Lyon, and Douglas. Indeed, Roger C. Smith lists *B. sigmaterus* among the most common species of *Bittacus* found in Kansas.

HABITAT.

The home of *Bittacus stigmaterus* is the moist, shady woodland, out of the reach of the sun's rays. Here the hanging-flies suspend themselves by their long slender fore limbs to the lower branches of shrubs and weeds. Such a position is seldom over a few inches above the surface of the ground, but occasionally some have been observed in rank growths of buck brush, *Symphoricarpus orbiculatus*, at a higher distance (two or three feet).

Once a place is found in which these insects occur, there they may be found from year to year, generally in great numbers. A farm near Lawrence, Kansas, has for many years been a fertile place for hanging-flies. Here they make their appearance in early July and remain until September in apparently never-decreasing numbers. It is of much interest to note that we have found that two species occur here within an area which is less than one hundred feet square. During the first part of July, *B. strigosus* is the common and, in fact, the only species for a time. But by August and September it is no longer to be found. *B. stigmaterus* has appeared and become the dominant form in the very place where *B. strigosus* once thrived. This change takes place gradually. Hence, *B. strigosus* may be termed an early occurring species and *B. stigmaterus* a late occurring one.

Furthermore, I have observed that *B. stigmaterus* gradually collects in the damper part of the woodland with the advance of summer. It is a common thing in late August to find many of these insects assembled among the clumps of grasses and other plants near the very edge of a shaded pool or stream. In such places there are generally swarms of many kinds of dipterous insects, furnishing a generous supply of food for the hanging-flies.

HABITS OF THE ADULT.

FLIGHT.

Bittacus stigmaterus seldom flies, except when disturbed or when torn from its support by its resisting prey. Even when these few flights are made they are for only a short distance, seldom over two or three

feet at a time, and just barely above the top of the dense herbage. In fact, the long, slender spiny legs often are caught upon the foliage, causing the flight of the insect to appear stumbling and awkward.

When the hanging-flies are disturbed by the collector, great numbers of them may often be seen flying just a few feet ahead of him as he walks along slowly through the thick herbage. In this way I have been able to drive large numbers of them into a single nook or corner of the woods.

In the laboratory I have seen them fly about carrying their prey with them by means of their hind tarsi, but none while on wing have been observed to attempt to catch prey. Some individuals in the laboratory which had escaped from my cages have been found to fly to a height of eight feet.

WAITING FOR PREY.

The hanging-flies do not sit upon the surface of the foliage of plants, but hang suspended by their front legs from some branch or leaf. Very often one leg or the other of the middle pair assists in this hanging position. In their suspended position the front pair of legs are bent so that the head is elevated somewhat above the fore femora, thus allowing the head to be freely moved from side to side. The two middle legs are generally extended in front and slightly outward on each side. Likewise, the two hind legs are protruded in front of the body but at a lower level. Thus the whole makes a circular trap of dangling legs for the unwary prey. I have seen *B. stigmaterus* hang quietly for hours in such a position waiting for its food.

FEEDING.

Bittacus stigmaterus is a typical predacious insect. In its ability to capture prey it equals, if it does not excel, the preying mantis. The slender dangling legs remain perfectly motionless until a fly or some other insect is well within their reach, even at times allowing the insect to fly through the trap once or twice unmolested. But suddenly the armed tarsi seize the unfortunate passer. Often *B. stigmaterus* is actually torn from its support when the captive struggles for its life; yet the hold is seldom relinquished. The fourth and fifth hind tarsal segments are generally securely coiled about the base of the fluttering wings. Then the victim is lifted to the mouth and only the soft parts and body fluids are eaten, hence nearly all of the prey's body is left after feeding. But fifteen or twenty minutes is required for the completion of a meal, at the end of which time the lifeless remains are dropped upon the ground. (*B. stigmaterus* has been observed to continue its chewing movements for some little time after feeding.)

I have found this species to eat nothing but living insects. All of the following have been eaten by my caged specimens:

House-flies, *Musca domestica.*
Pomace-flies, Drosophilidæ.
Crane-flies, Tipulidæ (some species of which were larger than *B. stigmaterus*).
Long-legged flies, Dolichopodidæ.
Mosquitoes, *Culex.*

These insects are also cannibalistic. I found one individual feeding upon one of its comrades when there was no other food provided.

B. stigmaterus requires a considerable amount of food; in fact, some of my caged specimens could have eaten more food than I had for them. I have observed several individuals seize as many as three Drosophilid flies at a single time, one being held by each of the hind feet and one by a middle leg. Ninety of these small pomace-flies were devoured by a single *Bittacus* in less than two days. One female ate eighteen house-flies in a single day, while another ate thirty-two in two days. Further information regarding the amount of food eaten by a single individual per day may be obtained from the following table:

Cage No.	Sex	Kind of Insects Eaten	No. of Insects Eaten
1	Female	Drosophilidæ	5
2	Female	Drosophilidæ	12
3	Male	Drosophilidæ	10
4	Female	Drosophilidæ	32
5	Male	Drosophilidæ	30
6	Male	Dolichopodidæ	3
7	Female	Dolichopodidæ, 5 Drosophilidæ, 4	9
8	Female	Drosophilidæ	20
9	Female	Dolichopodidæ, 6 Drosophilidæ, 3	9
10	Female	*Musca domestica*	18
11	Female	Dolichopodidæ, 8 *Culex*, 7	15
12	Female	Drosophilidæ	11
13	Female	Dolichopodidæ, 5 *Culex*, 3	8
14	Female	Drosophilidæ	4
15	Female	Dolichopodidæ, 7 *Culex*, 4	11

Although the hanging-flies will eat almost any small insect which might fly around near them, they have a preference for the Diptera. The time required to eat a single fly was found to be quite variable. One female required 40 minutes, while another needed 50 minutes to eat the soft parts and suck the body fluids of a house-fly. These two cases were the longest periods required according to our observations. The average time was about 20 minutes.

CLEANING UP.

Following each feeding, the hanging-fly performs its toilet. This I have found to be true for both *Bittacus strigosus* and *Bittacus stigmaterus*. Furthermore, careful observation has shown that the "cleaning up" habit may be divided into some half dozen more or less definite steps. For *Bittacus stigmaterus* these are as follows:

(1) Both the hind and middle pair of legs are extended forward making an angle of approximately forty-five degrees with the under side of the abdomen. Then a single middle leg is drawn back and forth between the hind legs which remain extended and held tightly together. Often the hind legs are braced in their extended position upon an adjacent twig, instead of being held in a free position.

This first step in the "cleaning up" process is invariably repeated many times in succession. Moreover, the leg used in the rasping movement is alternated with the opposite leg of the same pair from time to time.

(2) A single middle leg is raised in such a position that the mouth parts, head, and neck are easily wiped upon the lifted femur. Again, a single wiping is not sufficient, a number of repetitions is necessary. But there is seldom an alternation with the opposite leg in this case.

(3) The leg just used as a wiper for the head region is returned to the normal position and is drawn a number of times through the tightly extended hind pair of legs in much the same fashion as in the first step. However, the movable leg in this procedure is frequently simply raked upon the spiny sides of any one of the extended legs.

(4) Sometimes step (2) is repeated and followed by a repetition of step (3). The same leg that was used before, or the opposite leg of the same pair may be employed.

(5) Both a fore and hind wing are extended side by side in front of the body. In this position they are held between the tarsi of the hind and middle legs of the same side. Then these tarsi are slowly raked upon the outer surface of the contiguous wings.

In the concluding of this step the hind legs cease to serve as rasping organs, but have as their function merely that of holding the wings in position while the tarsus of a leg on the opposite side is scraped along the free margins of the wings. After this has been done two or three times, the wings are allowed to return to their normal position.

(6) Finally, the whole abdomen is lifted to a position where it is easily brushed on both sides by the hind femora. Several strokes made by these organs conclude a complete "cleaning up."

The description just outlined is in the main followed by hanging-flies of this species. But occasionally individuals have been observed to deviate from the normal procedure. For example, I have seen the extended tarsi worked against each other immediately following step (5) and before step (6) was undertaken. Furthermore, it is well to note the toilet may be discontinued at any time if the insect should be disturbed or if its prey should come near during the process. But if no distractions of any sort occur, the "cleaning up" may be repeated several times.

It should also be mentioned that the insect will brush the long legs, one upon the other, even though no food has ever been eaten. This fact has been demonstrated by newly emerged adults not provided with any food.

MATING.

Brauer gives the following account of his observations of the mating habits of *B. italicus:* "While the female is feeding a male appears sooner or later and mating occurs. In the process both sexes hang with their ventral sides together. Copulation may require hours, but often it is done in a short time. The male does not die immediately, but often seeks out another mate." The writer has not yet been successful in observing the copulation of hanging-flies either in the field or in the laboratory.

EGG LAYING.

My first observation (August 20, 1929) on the oviposition of *Bittacus stigmaterus* is characteristic:

I.

The cage was taken from a semi-lighted room at 9:00 P. M.

Three eggs, which had but recently been laid, lay upon the bottom of the cage.

The adult was found with the end of her beak resting firmly against the bottom of the cage and with her long legs held out on both sides of the body in a supporting fashion.

The abdomen was lifted some distance from the bottom of the cage. It was held in a rigid position, except for a slight muscular movement which was apparently an effort to work the egg out of the body. Even when completely exposed the egg hung at the tip of the abdomen and did not drop upon the floor of the cage until she made a sudden jerk with her wings.

II.

She then flew up and took a new position only a few inches distant.

She assumed the same position as before, except for the fact that the wings were fully extended this time in a horizontal position.

In about 15 minutes she deposited another egg in much the same manner as before. Again, the egg remained for a time at the posterior end of the body and required a quick jerk of the wings to loosen its hold.

III.

Without moving to a new position she laid a third egg within less than 10 minutes.

She did not hold the wings extended this time. Furthermore, the egg fell upon the bottom of the cage without any special movement of the wings.

This individual deposited a total of 17 eggs in less than 2 hours.

From all observations made on the egg-laying habits of *B. stigmaterus*, we are led to conclude that the eggs are laid singly and at random over the surface of the ground. Moreover, we have found that a single female may deposit eggs at various intervals throughout her life time.

The exact number of eggs laid by different individuals has been found to be quite variable. One female laid 60 eggs in 5 days; others

have laid but 1 or 2 eggs in the same length of time. A very accurate record concerning the production of eggs by *B. stigmaterus* (each cage contained a single female) is given in the following table:

Cage No.	Number of Days	Number of Eggs Laid	Cage No.	Number of Days	Number of Eggs Laid	Cage No.	Number of Days	Number of Eggs Laid
1	5	60	21	1	4	41	1	1
2	1	5	22	1	3	42	1	11
3	5	44	23	4	49	43	1	14
4	1	4	24	1	4	44	1	3
5	1	8	25	4	25	45	2½	5
6	4	3	26	1	5	46	1	12
7	1	5	27	1	4	47	3	26
8	1	2	28	1	9	48	1	4
9	1	15	29	3	0	49	2½	0
10	4	2	30	1	12	50	1	1
11	1	1	31	2½	0	51	1	21
12	3	7	32	1	6	52	2½	0
13	1	9	33	1	1	53	2½	1
14	3	1	34	2½	6	54	1	2
15	1	7	35	1	4	55	1	0
16	1	12	36	1	0	56	1½	10
17	1	10	37	1	6	57	1½	14
18	3	1	38	1	3	58	1½	0
19	1	19	39	2½	0	59	1½	4
20	5	8	40	1	4	60	1	2

LIFE HISTORY.

THE EGG.

Eggs of *Bittacus stigmaterus* are laid during the summer months from July to September, and remain unhatched throughout the winter. That the egg is the overwintering stage has been definitely proved. I have had in my possession over 900 eggs, all of which passed the winter in a perfect condition.

The egg of *B. stigmaterus* is indeed peculiar. It is rectangular in shape, and each of the six surfaces bears a central depression. It has a thick, hard leathery shell. The outer surface is very rough, in fact, under the compound microscope it appears to be a mass of various sized spherical granules. This outer shell is dark brown in color, though some eggs of a lighter color have been found. To the naked eye it appears to be but a particle of soil. The dimensions of a newly-laid egg are approximately .6 mm. x .5 mm. x .5 mm. See the accompanying illustrations of both a side and end view of an egg of *B. stigmaterus*, Figs. 1 and 2.

I have found that moisture must be provided if the eggs are to hatch. All of the 150 larvæ of *B. stigmaterus* which I have seen were hatched from eggs that had been provided daily with moisture for two or three weeks previous to the time of hatching. And no eggs while entirely dry have been known to hatch. These findings cor-

respond very closely to those obtained by Brauer in 1865 for *B. italicus*. This work on the European species is stated by Packard as follows: "And now a remarkable fact has been noticed by Brauer. He has observed that if the marshy or wet ground, where the female *Bittaci* customarily lay their eggs, does not dry up, no females appear until the second year following; so that the eggs lie over unhatched two years. The first condition of their hatching is a complete drying of the earth in which the eggs lie; the second condition is a succeeding thorough wetting of the ground in the spring. If the ground remains dry from want of snow in the winter, or rain in the spring, and there follows in the next summer a very thorough wetting of the soil, then the time of appearance of the adults will be retarded three or four months."

Freezing does not seem to be essential for hatching. Eggs kept in-doors during the winter hatched as well as those which were kept outside.

I have observed the eggs of *B. stigmaterus* in every case to begin to enlarge about a week or ten days before hatching and continue to do so until surprisingly large proportions are reached before the larva leaves the egg. The largest diameter of the newly laid egg is only .6 mm. but that of the egg before hatching is 1.1 mm. During the period of incubation the egg loses its rectangular shape and assumes a perfect spherical form.

The larva leaves the egg through an irregular opening cut through the tough leathery shell. Fig. 3.

The table given below shows the duration of the egg stage. Although this applies to but a very few of the eggs incubated in the laboratory it is typical for the species.

Date of Laying	Date of Hatching	Total Number of Days in Egg Stage
July 28, 1929	March 7, 1930	222
July 25, 1929	February 26, 1930	216
July 30, 1929	March 12, 1930	225
July 29, 1929	March 8, 1930	222
July 25, 1929	March 2, 1930	220
July 27, 1929	March 5, 1930	221
July 28, 1929	March 9, 1930	224
July 26, 1929	March 7, 1930	224
July 29, 1929	March 11, 1930	225
July 28, 1929	March 6, 1930	221
July 29, 1929	March 16, 1930	230
August 3, 1929	April 3, 1930	243
July 19, 1929	April 1, 1930	256
August 6, 1929	March 25, 1930	231
July 27, 1929	March 9, 1930	225
July 27, 1929	March 11, 1930	227
July 25, 1929	March 12, 1930	230
July 26, 1929	March 12, 1930	229
August 17, 1929	March 28, 1930	223
July 29, 1929	March 6, 1930	220

The first larvæ of *Bittacus stigmaterus* to be seen by us hatched on September 21, 1929 from an egg laid July 25, 1929. This rapid development is not the normal occurrence, but is recorded here to show that exceptions to the normal development do occur.

THE LARVA.

Structural Description—The larva of *Bittacus stigmaterus* is cylindrical with a rounded head. On the dorsal side it is adorned with two prominent rows of spines (except on the first and last segments) each of which bear a long terminal whip in addition to a pair of distinct knobs near the base. But the spines on the eighth and ninth abdominal segments are different in that they lack the long terminal whip and bear three basal knobs instead of just two. The tenth segment bears a single spine similar to those on the two preceding segments but it is entirely lacking in any basal knob. The first thoracic segment is peculiar in that it is furnished with six spines bearing terminal whips but all of these point forward forming a collar-like structure about the base of the head. Fig. 4.

Both sides of the body are provided with a single row of spines much like those on the dorsal side, except for their smaller size. Here, again, the first thoracic segment and the last three abdominal segments are different from the rest. This segment of the thorax possesses no spines. The ninth and tenth abdominal segments bear a single spine-like hair. Just above the base of each lateral spine is a single seta on each segment.

On the lateral margin of the ventral side of the abdominal segments (except the tenth segment which will be described separately) is a row of spines. On each segment it consists of three bristle or hair-like spines of which the middle one is longer than the other two. Each of these nine abdominal segments bear a pair of short median prolegs on each side of which is a single short spine. Fig. 6.

The ventral side of the last or tenth abdominal segment is very interesting for it is provided with a very efficient posterior sucker which is used as an aid in locomotion. This is shown fully extended both from a lateral and a ventral view in Figs. 8 and 9. The surface of this posterior segment is comparatively smooth except for a few short scattered spines and two longer ones on its lateral margins above the sucker.

The three thoracic segments bear on their ventral surface a pair of prominent legs. These legs are fairly sharply pointed and are furnished near their basal segments with a few scattered spines.

The head is rounded at the vertex and is normally so completely bent under the body as to be entirely hidden by the thorax when viewed from above. There is a single median ocellus on top of the head. There are two larger eyes, one borne on each side of the head near the base of the antennæ. These are not true compound eyes but are simply a group of several ocelli. The antennæ are prominent, stout, two-segmented structures. The mandibles are large and heavily chitinized. Collectively the mouth parts give the front of the face a

wedge-shaped appearance. The entire head is clothed with short spines arranged in a definite fashion as shown in the accompanying illustration. Fig. 6.

In the newly hatched larva the thorax and abdomen are light gray in color; the head, which is then always a more conspicuous structure than later, is dark brown. In the older larva the cuticula of the entire body becomes a slate-gray color and is very warty in appearance, for the small particles of sand and sediment adhere to the outer surface. The older larvæ differ from the young larvæ not only in being darker colored and having a relatively smaller sized head, but also their long whip-like dorsal spines are not distinctly knobbed.*

Larval Habits.—The young larvæ upon hatching from the egg escape from an irregular opening made in the wall. They feed upon their own egg shell, in most cases devouring it completely, but in many cases they do not. At this early age they are very active and wander around apparently in search of food. All of my 150 larvæ were fed very small pieces of fresh beef steak which they ate fairly well, especially while they were quite small. But the older larvæ seemed to prefer to bury their heads in the soil or about the roots of moss plants which I would provide. A few of these older larvæ have been actually observed to chew at pieces of dead moss roots and even tender green blades of grass. Since the older larvæ are very sluggish in their movements over the surface of the soil and seldom move unless disturbed they undoubtedly do not capture living prey. As a further proof of this, many small living earthworms, crustaceans, and insects were provided but all were refused.

The very young larvæ have the interesting habit, when disturbed, of standing almost perpendicularly on the posterior end of the body with the head and thorax coiled under the ventral side of the body. The young as well as the older larvæ feign death for a considerable length of time.

On molting, the head is a shiny light brown and the thorax and abdomen are a semi-transparent grayish color. The larva at once feeds upon the skin as soon as shed. For this reason it was quite difficult to determine the number of molts with any accuracy.

In about one month my larvæ entered the soil through a characteristic opening made by them. This is shown in the accompanying illustration. Fig. 7.

The rate of growth for one was as follows:

*Brauer (1865) after observing the European species *B. italicus* for twelve years, found only six larvæ, all of which died at the end of twenty days. His description of the larvæ of this foreign species corresponds in general to that here given for the American, *B. stigmaterus*.

LARVA No. 1.
EGG HATCHED MARCH 13, 1930.

Date	Length of Body in mm.	Width of Body in mm.	Date	Length of Body in mm.	Width of Body in mm.
March 13.....	2.55	.43	March 29....	7.23	1.91
March 14.....	2.98	.43	March 30....	7.65	1.91
March 15.....	2.98	.64	March 31....	8.08	2.13
March 16.....	2.98	.64	April 1.....	8.50	2.13
March 17.....	3.19	.64	April 2.....	8.93	2.34
March 18.....	3.40	.64	April 3.....	9.35	2.34
March 19.....	3.40	.64	April 4.....	9.35	2.34
March 20.....	3.83	.85	April 5.....	9.35	2.34
March 21.....	4.25	.85	April 6.....	10.08	2.55
March 22.....	4.47	1.06	April 7.....	10.41	2.55
March 23.....	4.66	1.06	April 8.....	11.00	2.96
March 24.....	5.10	1.28	April 9.....	11.48	3.19
March 25.....	5.53	1.49	April 10.....	11.90	3.40
March 26.....	5.95	1.46	April 11.....	11.90	3.40
March 27.....	6.38	1.70	April 12.....	(Went into the soil)	
March 28.....	6.80	1.70			

The length was determined when the larva was extended its full length ready to move; the width was taken from tip of one dorsal spine (not including the hair-like whip) to the tip of the other.

Five other larvæ spent 26 days each in the larval stage, one spent 28 days, and another took 36. All these were kept in the laboratory at house temperature.

The largest larva became 13.90 mm. long.

THE PUPA.

Nowhere in the literature available is there any record of the pupal stage of any species of *Bittacus*, either American or European. Brauer's six larvæ of the European species *B. italicus* died before pupating, and Felt states that even the larva of the American species *B. strigosus* remained unknown to him. Hence, the many pupæ of *B. stigmaterus* which I obtained in the laboratory during the month of April, 1930, seem to be the first to be seen for any species of *Bittacus*.

The Pupal Cell.—As already mentioned, the full grown larva enters the soil by way of an opening of its own construction. This entrance is circular and surrounded by a nicely constructed ridge made of particles of earth mixed with saliva. It resembles a miniature opening of a crayfish burrow. From this there leads a short circular tunnel to the oblong pupal cell itself. This subterranean cell is also circular but of a larger diameter than that of the entrance. Fig. 10.

Here, inside the cell, the larva molts. The molted skin of the larva may readily be found at the extreme end of the earthen chamber.

Description of the Pupa.—The pupa of *Bittacus stigmaterus* is exarate, that is, the appendages are free. Fig. 11. The head is held tightly

against the ventral side of the body and the antennæ lie closely against the dorsal side of the thorax. The femur of each front leg is likewise held closely against the side of the thorax and extends upward at approximately a forty-five degree angle, with the remaining segments bent ventrad to the abdomen. The middle pair of legs assume a position quite similar to that of the front pair. The femur of each of the hind legs extends downward at an angle of forty-five degrees on either side of the abdomen with the tibia bent forward and lying closely appressed against the full length of the femur. The hind tarsi meet on the ventral side of the abdomen as do those of the other two pairs of legs. The delicate wings are also held closely against the sides of the body but have their apices extending considerably forward, thus protecting the tarsi. The abdominal segments are exposed on their dorsal side. They are larger and furnished with setæ arranged in characteristic fashion as shown in the illustration. The pupa is of a uniform gray or brownish-white color, except the large compound eyes, which are dark brown.

The pupal stage lasts a little longer than two weeks. The following table gives the duration of the pupa for ten individuals reared in the laboratory.

Date Larva Entered the Soil	Date Adult Emerged	Total Days for Pupal Stage
April 15	April 30	15
April 12	April 29	17
April 17	May 2	15
April 2	April 17	15
April 11	May 1	20
April 6	April 23	17
April 12	April 30	18
April 11	April 30	19
April 13	May 1	18
April 2	April 17	15

THE ADULT.

The adult hanging-fly emerges from the soil by way of the opening through which the larva entered. The cast skin of the pupa is always left projecting from the opening. The new imago is at first light colored but it becomes the normal color in about a quarter of an hour.

The adults make their appearance about the middle of July and disappear by the first of September. However, I have collected a few specimens as late as September 12, but certainly this is very unusual in this part of the state.

The life of a single adult is doubtlessly short. The length of life of individuals in captivity varied from 1 to 7 days. Only two, one male and one female, out of over 100 specimens have been known by us to live over 7 days.

That the females do not live as long as the males under the same conditions is evident from the following table of the record of twenty-eight cages, each cage containing one male and one female.

Cage No.	Duration in Days	Female	Male
1	3	Dead	Living
2	1	Dead	Living
3	6	Dead	Living
4	1	Living	Dead
5	1	Dead	Living
6	1	Dead	Living
7	1	Living	Dead
8	1	Dead	Living
9	3	Dead	Living
10	1	Living	Dead
11	1	Dead	Living
12	6	Dead	Living
13	1	Dead	Living
14	3	Dead	Living
15	1	Dead	Living
16	1	Dead	Living
17	3	Dead	Living
18	1	Dead	Living
19	1	Dead	Living
20	3	Dead	Living
21	3	Living	Dead
22	1	Dead	Living
23	1	Dead	Living
24	1	Dead	Living
25	1	Living	Dead
26	1	Dead	Living
27	6	Dead	Living
28	3	Dead	Living

In concluding this account of the life history of *Bittacus stigmaterus*, it is well to summarize the time required for each stage of the metamorphosis. For one of the first individuals to be reared in the laboratory it is as follows:

Complete Life History of a Single Hanging-fly, *B. Stigmaterus*.

Stage	Date	Total Days
Egg	July 28, 1929—March 6, 1930	221
Larva	March 6, 1930—April 1, 1930	26
Pupa	April 2, 1930—April 17, 1930	15
Adult	April 17, 1930—April 22, 1930	5

It was also found that the average time required for the different stages was as follows:

Egg	226 days
Larva	28 days
Pupa	16 days
Adult	5 days

NATURAL ENEMIES.

True it is, that the hanging-fly imperils the life of many insects even larger than itself. Nevertheless, certain species of the family Asilidæ are able to terrorize the life of *Bittacus*. These robber-flies have been frequently observed flying about over areas inhabited by *Bittacus stigmaterus* and I have seen them fly through the air carrying the lifeless remains of hanging-flies.

Furthermore, there are certain little red mites that occasionally attack *B. stigmaterus*. In spite of the frequent toilets made by its host, these creatures are able to adhere to a femur or some other part of the body.

MODIFICATION OF THE LEGS.

No other insect is known that can use its hind legs to capture its prey. This adaptation is peculiar to the genus *Bittacus*. Such a use of the hind pair of legs would seem to be very awkward, but anyone who has seen these insects feeding would testify quite to the contrary. This efficiency, however, has been gained at the expense of the ability to use these structures as a means of locomotion. The hanging-fly cannot walk or even support the body on its long legs in the ordinary way. If several individuals be placed in a small box their long legs become entangled into a helpless mass.

TECHNIQUE.

COLLECTING SPECIMENS.

The adult insects used in my experiments were taken from a farm near Lawrence, Kansas, and one near Emporia, Kansas. The instrument used for collecting was simply a large lamp chimney, the top end of which was closed with a piece of cheese cloth held in place by a rubber band. By holding this at the top end, the large basal opening was quickly thrust over the insect as it hung quietly from some support. Then by holding the palm of my hand over the opening the captive was carried to a wooden box about 18″ x 16″ x 12″, provided with several twigs to serve as supports for the insects, and furnished at one end with a closeable opening about the size of the base of the lamp chimney. When the opening of the chimney was placed against that of the box the hanging-fly was allowed to enter the container.

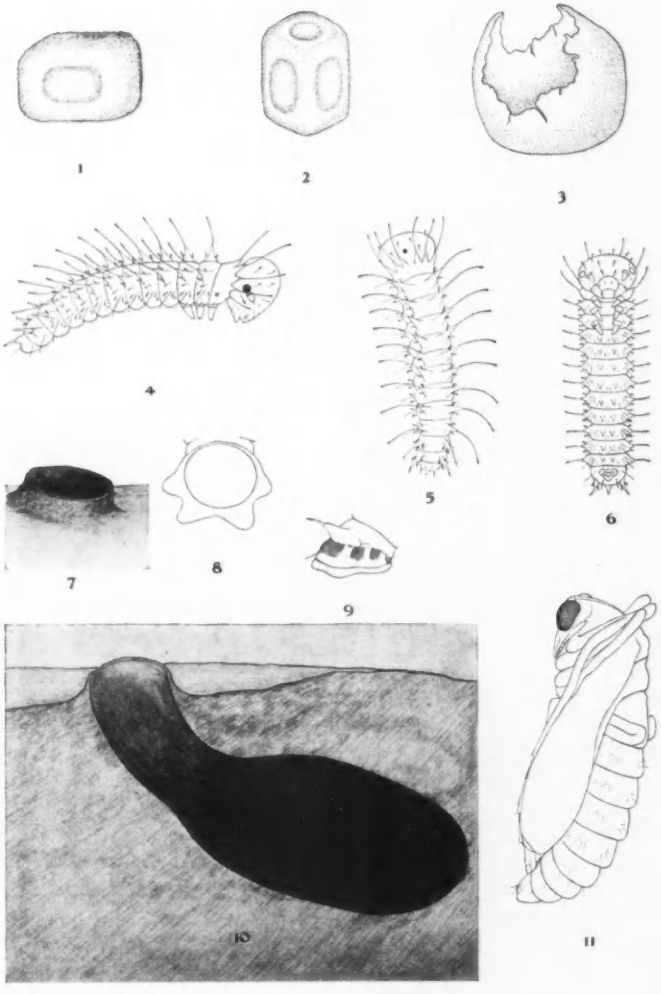
An ordinary insect net was not found to be satisfactory in the collecting of these insects. Many individuals were injured either by the sweeping of the grass or on being removed from the net.

THE CAGES.

The ordinary Mason glass fruit jar was found to be very satisfactory for individual cages or even for a single pair of these insects. The mouth of the jar was covered with a small piece of cheese cloth held in place by a rubber band. Each jar was provided with a small twig on which one or two insects might hang. Such cages were advantageous

Bittacus Stigmaterus Say
Laurel Raymond Setty

PLATE 1.



1. Side view of egg.
2. End view of egg.
3. Egg shell after hatching, showing enlargement of egg.
4. Lateral view of larva.
5. Dorsal view of larva.
6. Ventral view of larva.
7. Mouth of pupal cell.
8. Ventral view of larval sucker.
9. Lateral view of larval sucker.
10. Section through pupal cell.
11. Pupa.

for the following reasons: (1) they were convenient to handle; (2) the hanging-flies seemed to be more satisfied in this sort of cage than in any other tried by us; (3) the insects could be easily transferred from one jar to another; (4) the eggs were readily collected by simply inverting the jar; and (5) small flies and other insects placed in the jar for food could not escape.

All cages were kept upon a table in a basement room near a large container of water, thus providing the necessary shade and moisture.

PROVIDING FOOD.

In order to have a sufficient food supply of living insects for the hanging-flies, it was necessary for me to raise pomace-flies, *Drosophila*. This was done by allowing them to breed upon pieces of ripe banana in fruit jars. To introduce a fresh food supply into a cage, I simply inverted a hanging-fly jar over one swarming with Drosophilid flies.

CARE OF THE EGGS, LARVÆ, AND PUPÆ.

The most convenient containers for keeping the eggs were small flower pot saucers lined with moist cellu-cotton over each of which the flower pot itself was inverted. By adding a small amount of water each day, the eggs were kept moist.

After hatching, each larva was transferred to a similar container in which a small amount of soil and moss were placed upon the cellu cotton. Moisture and tiny pieces of beef steak were provided daily, to these containers.

When the larvæ had entered the soil to pupate less moisture was provided.

A QUANTITATIVE STUDY OF COPPER IN INSECTS.*

ROY MELVIN,
Department of Zoology and Entomology,
Iowa State College, Ames, Iowa.

Although considerable data have been accumulated regarding the quantity of copper in marine organisms (9), mammalian blood, (3), (5), milk (4), (10), and plant and animal foods, (2), (6), little is known regarding the quantity of copper in insects.

Muttkowski (7), (8) showed that copper was present in certain insects and in insect blood in quantities comparable to that present in the blood of crayfish, (*Cambarus* sp.). Since the amount of copper present in the crayfish blood was not given the above works possess but little quantitative value.

The purpose of this paper is to present the results of a quantitative study of copper in insects.

METHODS.

Extremely accurate quantitative studies on the copper content of insects necessitated the purification of all reagents employed in making such determination since traces of copper are commonly present in high-grade chemicals, even those marked, "C. P." Furthermore, ordinary distilled water quite often contains more copper than tap water. The water used in the preparation of reagents and final washing of all glassware was double distilled in pyrex. This still was constructed by sealing a 30-inch arm onto a 2-liter pyrex Claison flask. The advantages of such an arrangement lie in the fact that it is pyrex throughout, no rubber connections or the like, and that the possibility of contamination due to spray is minimized.

The apparatus described above was also employed in the purification of nitric acid.

The ammonia produced by dropping ammonium hydroxide upon solid sodium hydroxide was passed into copper free water,

*The author wishes to express his indebtedness to Mr. L. Goodhue, Chemistry Department, Iowa State College, for suggestions and criticisms during the course of the work.

in an ice bath, to give copper free ammonium hydroxide. In like manner, hydrochloric gas, liberated by the dehydration action of sulphuric acid on hydrochloric acid, was passed into water to give the copper free hydrochloric acid.

Copper determinations were made colorimeterically by the use of sodium diethyl dithio carbamate, $(C_2H_5)_2NCSS\ Na$. This reagent was first employed in the determination of copper by Callan and Henderson (1). 0.1% aqueous solution of this compound in the presence of copper gives a golden brown color. At a dilution of 1 part copper per 50 million of water a definite color is produced which is stable for more than an hour. Another distinct advantage of this reagent is that the reaction is the same in acid, neutral or alkaline solution. However, members of the iron-zinc group interfere and must be removed.

A stock copper solution containing 1 mg. copper per cc. was made by dissolving 3.9283 g. of $CuSO_4\ .5H_2O$ in water to make 1 liter. The standard copper solution containing 0.01 mg. copper per cc. was prepared by diluting 10 cc. of the stock solution (1 mg. per cc.) to 1,000 cc.

The steps in the analysis are enumerated below:

I. Weights, both fresh and dry.*
II. Digested in conc. nitric acid and evaporated to dryness.
III. Ashed to a white ash in a muffle furnace at a dull red heat.
IV. Ash taken up in conc. hydrochloric acid; made ammoniacal and filtered.
V. Filtrate made to 50 cc.
VI. Five or 10 cc. of the above solution is pipetted into a 50 cc. Nessler tube; 10 cc. of 0.1% sodium diethyl dithio carbamate solution added and water to mark. Shaken.
VII. A "known" is prepared by adding 5 cc. ammonium hydroxide, 10 cc. of sodium diethyl dithio carbamate solution to a 50 cc. Nessler tube; water to mark. Shaken. By means of a micro-pipette standard copper solution (0.01 mg. per cc.) is added until the color in the "known" matches that of the unknown. In the event that the sample contains only minute traces of copper, a "known" containing 0.03 mg. copper is prepared and copper added to the unknown until its color matches that of the "known."
VIII. Calculations.

Although some 600 copper determinations were made only those determinations in which the original weight of the sample was 5 g. or more are considered in this report. Some results of this study are tabulated in Table I.

*The material was dried in an electric oven at about 71° C. for 24 hours.

DISCUSSION.

In comparing the copper content of insects (Table I) with that of certain foods, (2), (6), it is evident that certain insects accumulate copper, *e.g.* the copper content of certain grain eating insects is higher than that of the food on which they live.

TABLE I.

Showing the Copper Content of Certain Insects and Insect Products.

Material	Percent Moisture	Mg. cu. per Kilo	
		Fresh	Dry
ORTHOPTERA—			
Periplaneta americana, adults.....(5)*	61.0	31.0	79.5
Blatta orientalis, adult males.....(8)	70.6	24.2	85.7
Blatta orientalis, adult females.....(19)	69.7	14.4	47.3
Blatta orientalis, adult females starved one week....(4)	67.6	6.1	18.8
Blatta orientalis, egg pouches.....(1)	62.1	21.3	56.0
Melanoplus femur-rubrum, adults.....(1)	68.8	21.6	69.3
COLEOPTERA—			
Trilibolium confusum, pupa.....(1)	59.8	25.9	64.5
Bruchus obtectus, adults.....(5)	48.2	31.3	60.4
Bruchus obtectus, adults dead in culture.....(2)	7.3	56.6	61.1
LEPIDOPTERA—			
Ephestia kuehniella, Larvae.....(1)	62.1	18.8	52.4
Samia cecropia, pupa male.....(5)	71.8	10.9	38.1
Samia cecropia, pupa female.....(6)	73.1	9.7	35.8
Samia cecropia, inner cocoon.....(1)	5.7	31.6	32.8
Samia cecropia, outer cocoon.....(1)	6.1	38.0	40.5
DIPTERA—			
Gastrophilus nasalis, larvae.....(1)	66.7	18.2	49.9
Gastrophilus intestinalis, larvae.....(1)	64.7	13.5	38.4
Cynomyia cadaverina, larvae on whole egg.....(1)	73.3	13.6	50.6
Cynomyia cadaverina, pupa on whole egg.....(1)	71.9	21.0	74.7
Cynomyia cadaverina, larvae on beef.....(1)	71.6	42.9	150.7
Blowfly, spp.? Larvae on chicken.....(3)	70.7	19.9	68.7
Blowfly, spp.? Pupa on chicken.....(1)	68.9	19.3	62.1

*These figures indicate number of tests.

Since studies on the physiological role of copper in insects will be presented in a later report it will suffice here to say that copper is present in greater abundance in the cast skins of *Melanoplus femur-rubrum*, empty egg cases of *Blatta orientalis*, and inner cocoon of *Samia cercropia* than in the insects by which they are produced. On the other hand copper was present in detectable quantities in newly hatched *Blatta orientalis*.

It seems worth noting, also, that the copper content of certain insects (*Cynomyia cadaverina*) varies with the material upon which they are feeding and in certain insects (*Blatta orientalis*) is materially reduced by starvation.

Studies on the copper content of insect blood indicate that copper is less abundant in the blood than in certain tissues and waste products.

CONCLUSIONS.

I. Copper is accumulative in insects and is influenced to some extent by the diet.

II. Certain waste products are higher in copper, on a weight basis, than the insects by which they are produced.

III. Copper is present in measurable quantities in certain insect eggs, newly hatched nymphs, larvæ, pupæ, and adult insects.

IV. The blood of certain insects is lower in copper content than the tissues and waste products of the same insects.

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HYDROGEN ION CONCENTRATION WITHIN THE DIGESTIVE TRACT OF CERTAIN INSECTS.*

MILLARD C. SWINGLE,
Assistant Entomologist, Bureau of Entomology,
United States Department of Agriculture.

INTRODUCTION.

Previous work on the hydrogen ion concentration of the digestive tract of insects has been somewhat limited to certain large species of the Orthoptera. Bodine (*1*)† has done the most of this work and has published the pH readings for seventeen species of Orthoptera. His results were as follows:

TABLE I.

THE pH OF THE CONTENTS OF THE DIGESTIVE TRACTS OF CERTAIN ORTHOPTERA (*1*).

SPECIES	pH VALUES			
	Crop	Coecum	Mid Gut	Hind Gut
Melanoplus differentialis adult	5.81	6.06	6.52	6.43
Melanoplus femur-rubrum adult	5.37	6.23	6.55	6.20
Melanoplus bivittatus adult	5.60	5.98	6.40	6.58
Melanoplus scudderi adult	5.43	6.23	6.66	5.86
Dichromorpha viridis adult	5.62	5.96	6.16	6.28
Arphia xanthoptera adult	5.60	6.03	6.46	6.40
Encoptolophus sordidus adult	5.72	6.25	6.58	6.32
Dissosteira carolina adult	5.75	6.05	6.30	5.95
Trimerotropis maritima adult	5.50	6.00	5.90	6.00
Scudderia furcata adult	6.00	5.90	6.10	7.30
Conocephalus ensiger adult	6.00	6.00	6.10	7.40
Microcentrum retinervis (?) adult	6.00	6.10	6.30	6.40
Schistocerca americana adult	5.40	5.75	5.80	5.75
Orphula pelidna adult	5.65	6.75	6.50	5.75
Spharagemon bolli adult	5.40	6.00	6.00	5.80
Chortophaga viridifasciata adult	6.00	6.90	6.95	6.80
Chortophaga australior adult	6.10	6.90	7.00	6.50

Wigglesworth (*6*) reports on two species of Blattidæ, *Blattella germanica* and *Periplaneta americana*. He reports the saliva as giving a pH value of 6.9, the crop 5.2, and the mid gut 6.2. When the insects were fed on a protein diet only, the pH of

*Contribution No. 78, Research Laboratories, Moorestown, New Jersey.
†Reference is made by number (*italic*) to Literature Cited, page 495.

the crop was 6.3 and that of the mid gut 6.4. When fed on a carbohydrate diet, the pH of the crop was 4.8 and that of the mid gut 6.3. Crozier (*3*) reports that the average pH values for chironomid larvæ are, fore gut 7.10, mid gut 7.50, and the hind gut 6.30. Swingle (*4*) gives the pH values of the larva of *Laspeyresia molesta* as follows: fore gut 7.20, mid gut 7.25, hind gut 7.20.

For the Orthoptera the readings were fairly constant throughout, the majority being slightly acid. Only a few observations have been made on species other than Orthoptera, and these have offered little chance for a comparison.

An observation by Wigglesworth, quoted above, is a very interesting one. He states that the hydrogen ion concentration is not a physiological constant for any one species, but that the concentration varies according to the type of food eaten. If this be the case, an average reading would have little more significance than an individual one, provided the latter were correct. It would have been much more interesting to have made but a single reading on a specimen about which all the factors of health, environment, and feeding were known, than to have presented a figure representing the average of several specimens about which nothing was known. However, this information was rather hard to obtain in the case of many species, so the orthodox method of averaging readings from a number of specimens was used. As explained above, this method is rather an antique one, but the information thus obtained will be of value and interest to those working on economic entomology. Each pH value given in Table II is the average of five readings, except as otherwise noted. It represents a general average of the specimens collected.

Specimens for this work were collected during the fall of the year. They were brought into the laboratory and dissected immediately so that fresh material would be assured. All were collected within a radius of 5 or 10 miles of the laboratory at Moorestown, New Jersey.

TABLE II.

THE pH OF THE VARIOUS REGIONS OF THE DIGESTIVE TRACT OF CERTAIN INSECTS.

Classification and Name of Insect	Fore Gut	Coecum	Mid Gut	Hind Gut
ORTHOPTERA.				
Oecanthus quadripunctatus. Tree cricket. A[3]	4.85	.....	6.85	6.22
Nemobius fasciatus. Small field cricket. A	6.05	.....	7.41	5.00
Gryllus assimilis. Large field cricket. A	5.23	7.82	7.55	7.48
Dissosteira carolina. Carolina locust. A	6.10	6.66	7.31	7.01
Melanoplus femur-rubrum. Red-legged grasshopper. A	5.48	.....	7.48	6.00
Paratenodera sinensis. Chinese mantis. A	5.12	6.60	6.69	6.23
Parcoblatta pennsylvanica. Wood cockroach. A.	6.34	.....	7.18	6.88
NEUROPTERA.				
Myrmeleon immaculatus. Ant lion. L[3]	7.01	.....	6.35	.....
ODONATA.				
Libellula luctuosa. Dragon fly. A	5.83	.....	5.37	6.28
HEMIPTERA.				
Arilus cristatus. Wheel bug. A	7.16	.....	5.70	6.31
(sp.?) Assassin bug. A	7.28	.....	5.50	6.00
Nezara hilaris. Green plant bug. N[3]	7.00	.....	7.15	6.09
COLEOPTERA.				
Cicindela (?) (sp.?). Tiger beetle. L	6.47	.....	M[3]	M
Harpalus caliginosus. Ground beetle. A	6.52	.....	7.68	5.72
Poecilus lucublandus. Ground beetle. A	6.63	.....	6.85	6.57
Gyrinidæ (sp.?). Whirligig-beetle. A	6.08	.....	5.90	M
Chauliognathus pennsylvanicus. Soldier beetle. A	7.05	.....	7.00	7.94
Epicauta pennsylvanica. Pennsylvania blister beetle. A	6.30	.....	6.20	5.70
Epicauta vittata. Blister beetle. A	6.15	.....	6.62	5.95
Meloe angusticollis. Oil beetle. A	6.20	.....	5.68	5.62
Alaus oculatus. Eyed elater. A	M	.....	7.15[4]	M
Melanotus communis. Click beetle. A	7.30	.....	9.1	7.26
Elateridæ (sp.?). Wireworm. L	M	.....	5.71	5.46
Elateridæ (sp.?). Wireworm. L	M	.....	6.00	5.38
Epilachna borealis. Squash ladybird beetle. A.	6.11	.....	6.69	6.58
Pelidnota punctata. Spotted pelidnota. A	6.11	.....	6.81	6.74
Pelidnota punctata. Spotted pelidnota. L	8.6	.....	8.7 to 9.5	7.87 to 7.20
Popilla japonica. Japanese beetle. A	7.28	.....	7.36 to 7.53	7.60
Popillia japonica. Japanese beetle. L	8.20	.....	9.5	7.58
Strategus septentrionis. Strategus. A	7.23	.....	6.74	6.11
Passalus cornutus. Horned Passalus. A	8.30	.....	8.6 to 9.3	8.15 to 5.90
Cerambycidæ (sp.?). L	6.57	.....	6.93	8.12
Parandra brunnea. Beetle. A	M	.....	6.18	M
Tetraopes tetraophthalmus. Milkweed beetle. A	M	.....	5.50	M
Diabrotica duodecimpunctata. Spotted cucumber beetle. A	5.91	.....	5.85	6.60

TABLE II—Continued.

Classification and Name of Insect	Fore Gut	Coecum	Mid Gut	Hind Gut
LEPIDOPTERA.				
Heliothis obsoleta. Corn ear worm. L.....	8.19	.....	8.00	M
Ceratomia catalpæ. Catalpa worm. L.....	9.2	.....	9.5	5.70
HYMENOPTERA.				
Camponotus herculeanus. Carpenter ant. A....	4.00[5]	.....	M	M
Polistes variatus. Wasp. A.....	6.80	.....	7.28	6.44
Vespa maculata. Hornet. A.....	5.31	.....	6.15	5.67
Bremus fervidus. Bumblebee. A.....	6.20	.....	6.48	6.25

[3]Abbreviations in table are as follows: A—adult; L—larva; N—nymph; M—amount of material too small for accurate test.

[4]Average of two specimens only.

[5]Average of two specimens only.

METHODS AND RESULTS.

The apparatus used in determinations of hydrogen ion concentration was a potentiometer circuit (*2*) with a modified quinhydrone electrode (*5*). The electrode was modified for the determination of very small quantities of the material to be tested, a cubic millimeter drop of which was placed upon a small platinum plate that acted as one of the electrodes. Quinhydrone was mixed into the drop by means of a small glass rod which had been drawn out to a sufficiently small diameter. The KCl-agar bridge from the potassium-acid-phthalate cell was drawn out to a moderately fine point to permit its being dipped into the drop on the platinum plate and thus completing the circuit. The set-up is exactly the same as described by Cole (*2*) and others, except that the platinum plate and agar point approach each other until they are joined by a drop of the solution to be tested instead of being submerged in a large quantity of the material to be tested in a flask or vial. This slight change in the electrode does not influence its sensitivity one way or the other. A series of check readings made on a neutral, standard buffer solution averaged 6.99. All the readings were practically constant.

The insects were dissected and pinned out in a paraffin dish and the contents of the various regions of the tract was removed with a micro-pipette, except in a very few cases where

the material was too solid, when it was removed with a micro-scalpel to a 0.5 cu. mm. drop of unbuffered, distilled water. The amount of material used in each test was measured by micro-pipettes which were drawn out to a fine point, one yielding drops 1 cubic millimeter in volume, the other 0.5 cubic millimeter in volume. The material to be tested was exposed to the air no longer than ten or fifteen seconds at the most, and the contamination of the material by the carbon dioxide in the air was thus reduced to a minimum. Only one reading was made with each insect to eliminate any effect which death might have on the acidity.

TABLE III.

THE TREND OF ACIDITY WITHIN THE DIGESTIVE TRACT OF CERTAIN INSECTS.

SPECIES	FORE GUT		MID GUT			HIND GUT		
	Pre	Post	Pre	Mid	Post	Pre	Post	Feces
Pelidnota punctata larva...	8.6	8.6	8.7	9.4	9.5	7.85	7.20	5.00
Popillia japonica larva.....	8.00	8.40	9.4	.....	9.5	7.60	7.50	5.50
Popillia japonica adult.....	.....	7.28	7.36	7.40	7.53	7.60	7.40	7.20
Passalus cornutus adult....	8.20	8.40	8.6	9.5	9.3	8.16	5.90	4.50

The greatest concentration of hydrogen ions in the insects tested was in the fore gut of the carpenter ant, *C. herculeanus*. This region gave a pH reading of 4. The concentration of hydroxyl ions was found to be very high in the mid guts of the larva of *Pelidnota punctata*, the larva of *Popillia japonica*, and the larva of *Ceratomia catalpæ*. This reading is approximately 9.5, but the exact reading can not be obtained by the use of the quinhydrone electrode. In solutions of high alkalinity, above pH 8.5, readings made with quinhydrone are much less accurate, and are not to be considered as the correct pH but more as a relative indication of the pH.

The hydrogen ions are usually less concentrated in the mid gut. In species having a digestive tract long enough to obtain material from a number of points throughout its length, a fairly regular gradation of the trend of pH was found. This is shown by the figures in Table III.

The results given in Table III show the trend of the pH from the mouth to the anus in three different species of insects.

Similar readings on other species, although not as complete as those given in Table III, have pointed to the possibility that the majority of insects have a similar pH trend throughout their digestive tract.

Slightly acid regions predominate in the digestive systems of insects. Table IV gives the percentages of the guts tested which were acid, and those which were neutral or alkaline.

From Table IV it appears that 55.2 per cent of the insects tested had a slightly acid stomach or mid gut, while 44.8 per cent had a neutral or alkaline stomach. Approximately 65 per cent of all the readings in Table II are only slightly acid or slightly alkaline, lying between pH 6 and pH 8.

TABLE IV.

PERCENTAGE TABLE FOR ACIDITY AND ALKALINITY IN DIGESTIVE TRACTS OF CERTAIN INSECTS.

Gut	Acid, Per Cent	Neutral or Alkaline, Per Cent
Fore guts	66.6	33.4
Mid guts	55.2	44.8
Hind Guts	73.5	26.5

No satisfactory correlation can be made from these results, between the acidity and the type of food eaten by the insect. In general it might be said that the mid gut tends to be more acid that the fore and hind guts in strictly carnivorous insects, while it is more alkaline in phytophagous species, but this is not always the case. Samples from larvæ seem to be much more alkaline than samples from the adult of the same species, especially among the Coleoptera. This probably is not true of the members of certain other orders.

SUMMARY AND CONCLUSIONS.

pH determinations made on the contents of the digestive tracts of approximately forty different species of insects showed a variation in acidity from pH 4 to pH 9.5.

From the determinations made it might be concluded that in the majority of insects the hydroxyl ion concentration increases from the mouth through the fore and mid guts, and

decreases from the posterior part of the mid gut through the hind gut.

The majority of the insects tested had a slightly acid tract.

No satisfactory correlation could be made between the acidity and the type of food eaten by the insect.

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BOOK REVIEW.

A MANUAL OF THE DRAGONFLIES OF CHINA, A MONOGRAPHIC STUDY OF CHINESE ODONATA.—By JAMES G. NEEDHAM. Published in Zoologia Sinica, Series A., Invertebrates of China, Vol. 11, Fasc. 1, 1930. Published by the Fan Memorial Institute of Biology, Peiping, China. Quarto pages, I–IV, 1–345, Index 1–11; 378 figures on 20 plates.

This volume describes 266 species of Chinese Odonata of which 58 are described as new. The area covered is given as "China," but individual references indicate that Hainan and the Japanese island of Formosa are included. The work is based on the literature and on material in American and Chinese collections. The list of "Describers of Chinese Dragonflies" on pages 7 and 8 shows that, excepting the 54 described in the present work, 195 were described by Europeans, with the types in Europe, 7 by Japanese and 2 by the American, E. B. Williamson. It is unfortunate that the author was not able to study types and material in European collections and particularly the collection of Dr. F. Ris, of Switzerland, who, when recently taken by death, was accumulating material for a volume on Chinese Odonata. The volume will stimulate interest among Chinese entomologists and thus bring to light the wealth of odonate fauna that must still be unknown in this vast and varied area.—C. H. KENNEDY.

THE INFLUENCE OF SOIL ACIDITY ON THE pH VALUE OF THE CONTENTS OF THE DIGESTIVE TRACT OF JAPANESE BEETLE LARVÆ.[1]

MILLARD C. SWINGLE,
Bureau of Entomology,
U. S. Department of Agriculture.

In determinations of acidity within the digestive tract of insects it is important to know the fluctuations in pH brought about by variations in the acidity of the food taken in. In order to answer this question for larvæ of the Japanese beetle (*Popillia japonica* Newm.) specimens from soil plots varying in pH were dissected and tested for acidity by a potentiometer circuit (*1*)[2] with a quinhydrone electrode (*2*).

From one to three larvæ were dissected from each of the ninety-two soil samples representing four different soil types. The pH value for the contents of the fore, mid, and hind guts of each of these larvæ was then obtained and the values arranged with the results shown in the tables. The pH value of the mid gut was approximately 9.5. and as this value is considerably beyond the limit of accuracy of the quinhydrone electrode (*1*, p. *52*), the values for the mid gut are not included in the tables. The values for the mid gut seemed to be as constant for the larvæ tested as those for the fore and hind guts.

Thirteen samples of potting soil were brought into the laboratory together with the larvæ found while digging the samples. This was done during the first part of October before the larvæ had stopped feeding for the winter. Three readings were made to determine the pH of the soil and the averages are presented in Table I. From one to three third-instar larvæ were obtained in each sample of soil and the pH values for the different regions of their digestive tracts are also given in Table I.

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[1]Contribution No. 82, Research Laboratories, U. S. Bureau of Entomology, Moorestown, N. J.

[2]Reference is made by number to Literature Cited, p. 502.

TABLE I.

THE pH VALUES OF THE CONTENTS OF THE DIGESTIVE TRACT OF JAPANESE BEETLE LARVAE FROM POTTING SOIL.

SAMPLE NO.	pH OF SOIL	pH OF INSECT	
		Fore-gut	Hind-gut
1	6.90	8.25	7.70
2	6.77	8.9	8.01
3	6.77	8.35	7.70
4	6.68	8.6	8.41
5	6.66	8.5	7.87
6	6.63	8.30	7.80
7	6.62	8.52	7.90
8	6.50	8.6	8.07
9	6.38	7.78	8.21
10	6.14	7.72	8.30
11	6.09	8.48	8.12
12	5.98	8.20	7.90
13	5.90	8.53	7.90

TABLE II.

THE pH VALUES OF THE CONTENTS OF THE DIGESTIVE TRACT OF JAPANESE BEETLE LARVAE FROM SANDY LOAM.

SAMPLE NO.	pH OF SOIL	pH OF INSECT	
		Fore-gut	Hind-gut
14	4.91	8.21	8.26
15	4.83	8.19	7.61
16	4.80	8.04	7.68
17	4.74	8.38	7.80
18	4.66	8.09	7.89
19	4.66	8.14	7.89
20	4.66	7.99	7.93
21	4.66	7.92	7.63
22	4.66	7.90	8.04
23	4.57	7.83	8.12
24	4.50	8.02	7.86
25	4.44	8.12	7.93
26	4.40	8.19	8.05
27	4.40	8.12	7.86
28	4.36	8.09	7.45
29	4.34	8.01	7.90
30	4.34	7.99	7.89
31	4.30	8.05	6.65
32	4.30	8.23	8.32
33	4.23	8.17	7.61
34	4.10	8.05	7.95
35	4.10	8.08	7.18
36	4.10	8.12	8.21
37	4.10	8.21	7.98
38	4.08	8.08	8.26

The thirteen samples of potting soil tested ranged in pH from 6.9 to 5.9. The pH values for the larvæ in Sample No. 13 were higher than those in Sample No. 1, although the reverse

TABLE III.

THE pH VALUES OF THE CONTENTS OF THE DIGESTIVE TRACT OF JAPANESE BEETLE LARVAE FROM SOIL CONSISTING OF SANDY LOAM AND PEAT.

SAMPLE NO.	pH OF SOIL	pH OF INSECT	
		Fore-gut	Hind-gut
39	4.95	8.32	7.98
40	4.83	8.20	7.98
41	4.80	8.11	7.82
42	4.74	8.50	7.65
43	4.74	8.10	7.90
44	4.69	7.98	8.02
45	4.68	8.01	7.90
46	4.66	8.08	8.01
47	4.66	8.04	8.06
48	4.60	8.14	7.63
49	4.57	8.08	7.82
50	4.57	8.12	7.92
51	4.51	8.32	8.16
52	4.47	8.30	7.79
53	4.42	8.16	8.20
54	4.40	8.04	7.54
55	4.40	7.92	7.95
56	4.38	8.28	7.92
57	4.32	8.18	8.32
58	4.32	8.20	7.61
59	4.32	7.83	8.16
60	4.23	8.25	7.68
61	4.23	8.28	8.05
62	4.23	8.21	7.95
63	4.18	8.12	8.05
64	4.15	8.08	8.21
65	4.10	7.99	7.98
66	4.08	8.30	7.86
67	4.08	7.83	7.99
68	4.08	7.87	7.98
69	4.05	8.21	7.43
70	4.02	8.17	7.95
71	4.00	8.04	8.12
72	4.00	8.63	7.80
73	4.00	8.20	8.88
74	3.99	8.17	7.89
75	3.98	7.98	7.83
76	3.98	8.11	8.01

is true for the pH values of the soil. The soil pH does not seem to exert a very definite influence on the pH within the insect.

The values in Table II were obtained in the same manner as those in Table I. The 25 samples were taken in a sandy loam soil instead of the clay loam and manure as in Table I.

The pH of the soil in Table II ranges from 4.91 to 4.08 but the pH values for the insects do not range in any order corresponding to that of the soil. They remain fairly constant throughout all the samples and are approximately the same as those reported in Table I. The soil reported in Table III ranges in pH from 4.95 to 3.98 and the pH values for the insects are approximately the same as those in Tables I and II.

TABLE IV.

THE pH VALUES OF THE CONTENTS OF THE DIGESTIVE TRACT OF JAPANESE BEETLE LARVAE FROM BOG SOIL.

SAMPLE NO.	pH OF SOIL	pH OF INSECT	
		Fore-gut	Hind-gut
77	4.42	8.21	8.32
78	4.00	8.15	8.20
79	3.64	8.21	7.18
80	3.58	8.16	7.86
81	3.58	8.32	7.93
82	3.55	8.10	7.88
83	3.54	8.32	7.95
84	3.42	8.05	6.65
85	3.40	8.30	7.61
86	3.40	8.50	7.68
87	3.28	8.22	7.85
88	3.21	8.20	7.45
89	3.20	8.19	7.45
90	3.20	8.20	7.76
91	3.13	8.01	7.26
92	3.00	8.63	7.61

The samples of bog soil in Table IV reach an acid value of pH 3, but the pH value for the insects taken in that sample were approximately the same as those in the other tables.

The values for the insects in Sample No. 1, Table I, are approximately the same as those for Sample No. 92, Table IV, despite the fact that there is a difference between the pH values of the soil corresponding to 3.9 units of pH. To compare more easily the results presented in the four tables, the averages of the soil pH and the pH of the insects were obtained and tabulated as in Table V.

One conclusion that may be drawn from these results is that the pH value of the soil has very little influence on the pH value of the contents of the digestive tract. As the larvæ pass much of the soil through their digestive tract while feeding, the high alkalinity recorded can only be maintained through the action of strong buffer salts in their digestive secretions. The chemical composition of these buffer salts will be partially described in another paper by the analysis of the entire inorganic contents of the digestive secretions. The physical character or strength of these buffers may be graphically presented so that their relative strength may be seen at a glance.

TABLE V.

TABLE OF AVERAGE READINGS OF THE pH VALUES OF THE CONTENTS OF THE DIGESTIVE TRACT OF JAPANESE BEETLE LARVAE FROM VARIOUS TYPES OF SOIL.

SOIL TYPE	SOIL pH	pH OF INSECT		
		Fore-gut	Mid-gut[a]	Hind-gut
Loam or potting soil.....	6.45	8.34	9.5	7.97
Sandy loam.....	4.45	8.08	9.5	7.83
Sandy loam and peat.....	4.37	8.04	9.5	7.94
Bog soil.....	3.47	8.23	9.5	7.72

[a]Values for the mid-gut are only approximate. See text.

This makes it possible to picture the relative strength of buffers in different regions of the tract, and also those from different insects.

A soil plot having an average pH of 6.6 was selected and several dozen healthy larvæ were obtained and brought into the laboratory for dissection. In addition, weak solutions of hydrochloric acid were made up in the following concentrations: 0.04 N., 0.08 N., 0.12 N., 0.16 N., 0.20 N., and 0.24 N. Several pipettes were also drawn out to a point sufficiently small to deliver approximately one cubic millimeter at each drop. An insect was then dissected and a cubic millimeter of the contents of the mid gut placed upon the platinum plate of the electrometric pH outfit. Its pH was quickly determined, after which a cubic millimeter of 0.04 N. hydrochloric acid was stirred into the drop and the pH again taken. Two insects were treated in this manner and four more with each successive

concentration of hydrochloric acid until the points shown in Figure 1 were obtained. The resistance or buffer strength of distilled water, adjusted to pH 9.5 with sodium hydroxide, was determined in the same manner for the sake of comparison.

A similar examination was made of the contents of the fore and hind guts with practically the same results. The buffer strength of the fore gut towards acid was just a little less than that of the mid gut, but that of the hind gut was slightly greater.

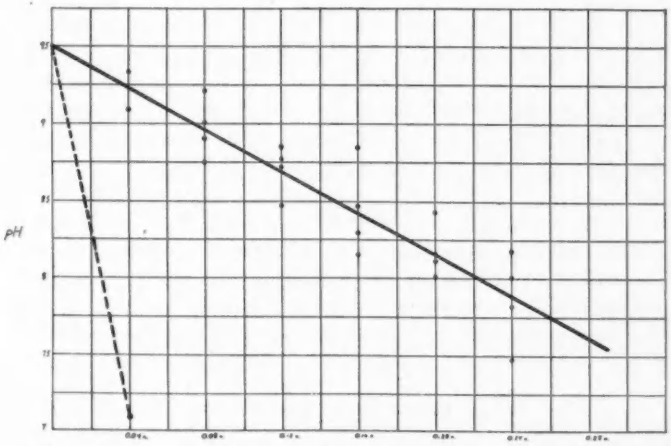

FIGURE 1. The buffering power of the mid-gut contents of Japanese beetle larvæ against acid solutions.

The graph shows the pH values resulting from the mixture of 1 cubic millimeter of the contents of the mid-gut and 1 cubic millimeter of hydrochloric Acid of the indicated normality.

Solid line: Buffer action of the mid-gut contents.
Broken line: Buffer action of distilled water.

In this connection it seemed that a comparison between the buffer strength of the digestive secretions of the larvæ and that of the soil might prove interesting. This was determined for the soil in the same manner as for the insects excepting that corresponding standard solutions of sodium hydroxide were used in place of hydrochloric acid. This was necessary in order to obtain information on the buffer strength of the soil towards the alkaline digestive contents. When titrating the soil with acid solutions it exhibits a buffering power almost

equal to that of the contents of the alimentary tract of the insect. However, when acid solutions are replaced by alkaline solutions, the buffering power of the soil was only about twice that given for distilled water in Figure 1. It is obvious, therefore, that the acid soil which is only weakly buffered against alkali will loose its pH value when brought in contact with the alkaline digestive secretions which are strongly buffered against acids. The result of the combination is a mixture having the pH value of the digestive secretions.

SUMMARY

Japanese beetle larvæ from soil samples varying in pH from 6.9 to 3.00 were dissected and the pH of the various regions of their digestive tract determined. From these results it was concluded that the pH of the digestive tract of the larvæ was not greatly influenced by the pH of the soil in which the larvæ fed.

The buffer strength of the fore, mid, and hind guts of the larvæ was practically the same towards acid solutions.

The soil was found to be only slightly buffered against alkaline solutions, thus accounting for the fact that the mixture within the digestive tract has a fairly constant pH regardless of the pH of the soil in which the larvæ were feeding.

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(1) **Cole, S. W.** Practical physiological chemistry. Seventh edition, pp. 30–52. Williams & Wilkins Co., Baltimore, Md. 1926.

(2) **Swingle, M. C.** Anatomy and physiology of the digestive tract of the Japanese beetle. Jour. Agr. Research **41**: 189–190. 1930.

BOOK REVIEWS.

BUTTERFLY AND MOTH BOOK—By ELLEN ROBERTSON-MILLER. Charles Scribner's Sons, New York, 1931. Price, $2.50.

This is a second edition revised and enlarged from an earlier popular book which has been a useful work in promoting interest in the study of these attractive insects.

The new edition contains six new chapters and a large number of additional illustrations, many of them photographs, of unusual excellence and which have been reproduced with beautiful effect. The accounts of personal studies of the habits and life-histories on a large number of our American species are written in a happy style well adapted to interest the beginner in insect studies and also to give much important detail concerning the activities and importance of these beautiful, but often economically destructive, insects. H. O.

THE DETERMINATION OF THE BLOOD VOLUME OF INSECT LARVÆ.

CHARLES H. RICHARDSON, ROBERT C. BURDETTE[1] AND CRAIG W. EAGLESON,[2]

Department of Zoology and Entomology,
Iowa State College, Ames, Iowa.

In physiological and toxicological studies of insects it is often desirable to know the volume occupied by the blood. Dry weight determinations of the whole insect furnish information upon the total quantity of body water, but tell nothing of its distribution, i.e., the quantity present in the blood and that held in the tissues. Furthermore, it is often important to measure the total quantity of a substance like glucose, uric acid, or of a poison like arsenic, that may be dissolved in the blood. A simple method for blood volume will afford this information. .

Two methods are described herein for the determination of the blood volume based upon examinations of the larvæ of the silkworm (*Bombyx mori* L.) and of the greater wax moth (*Galleria mellonella* L.). With slight modification they may be applied to many other insect larvæ and possibly to some adult insects.

Absorption method: The larva is etherized. When body movements have ceased, and any regurgitated liquid has been removed from the body surface with filter paper, it is weighed. The body is then quickly opened with dissecting scissors along the mid-ventral line from just above the anus to the head. In this operation care must be taken not to cut into the intestinal wall. The blood is absorbed from the body cavity with bits of filter paper until the walls of this cavity, and of the intestine, are practically dry. To facilitate complete removal of the blood, it is desirable to lift gently the intestine from the body cavity. The larva, now essentially freed of blood, is placed in a weighing bottle and weighed. The difference between the original weight of the larva and the weight after removal of the blood is the approximate weight of the blood. The weight of the blood divided by its specific gravity, which for the late instars

[1]Now at Rutgers University, New Brunswick, N. J.
[2]Now at Ohio State University, Columbus, Ohio.

of the silkworm is about 1.04[3], gives the blood volume in cubic centimeters. The results of nine determinations made by this method are given in Table I.

TABLE I.

Blood Volume of Larvae of *Bombyx mori* L. and of *Galleria mellonella* L.

Insect	Method	Wt. Larva in Grains	Blood Volume in c. c.	Blood Volume in c. c. per 100g. Body Weight
Bombyx mori.....	Absorption	0.7077	0.30	42.4
		2.0201	.79	39.1
		2.3545	.78	33.1
		2.4107	.75	31.1
		2.4913	.79	31.7
		2.8129	.94	33.4
		2.9307	.83	28.3
		3.2390	.93	28.7
		3.6820	.97	26.3
				Mean 31.2
Bombyx mori.....	Dry weight	.7603	.20	26.3
		1.6655	.57	34.2
		2.3511	.65	27.6
		2.4675	.63	25.5
		2.5456	.70	27.5
		2.7522	.84	30.5
				Mean 28.6
Galleria mellonella....	Dry weight	.5869	.12	20.4
		.1520	.06	39.5
		.1745	.09	51.6
		.1764	.07	39.7
		.1273	.06	47.1
		.1192	.06	50.3
		.1132	.05	44.2
		.1805	.09	49.8
		.1600	.06	37.5
		.2719	.16	58.8
		.2208	.05	22.6
		.1518	.08	52.7
		.1619	.08	49.4
		.1268	.07	55.2
		.0765	.04	52.3
		.1722	.08	46.4
				Mean 41.0

Dry Weight Method: (*Bombyx mori*). The larva is etherized, and after all body movement has ceased, and any regurgitated liquid has been carefully removed from the body, it is weighed. Then, holding the larva in the hand over a small weighed evaporating dish, the two posterior prolegs are snipped

[3]The specific gravity of the blood of *Galleria mellonella* is also about 1.04 (average of 7 determinations).

off with dissecting scissors, and the outflowing, yellowish-green blood is caught in the dish. After the flow of blood has ceased, an incision is made just back of the head large enough to insert the tip of a 50 c.c. burette. The burette is filled with distilled water. Water is now slowly passed from the burette through the larva into the evaporating dish until the liquid flowing from the severed ends of the posterior prolegs is colorless. Usually 10 to 15 c.c. of water are sufficient. When this point is reached, the tips of the other 4 pairs of prolegs are snipped off to determine by the color of the liquid issuing from them whether the lower portion of the body cavity has been freed of blood. If the removal of the blood is incomplete more water is passed through the larva. The evaporating dish with its contents of diluted blood is placed in a drying oven at 85° to 90° C., and the contents are dried to constant weight. The figure thus obtained is the dry weight (total solids) of the blood of the larva. The blood volume may be obtained by dividing this value by the dry weight of 1 c.c. of blood. The latter figure is found by making a separate determination of the dry weight of a known volume of blood. In nine determinations each of 10 c.c. of blood taken from larvæ in the fifth instar the weight per c.c. varied from 0.0781 gm. to 0.1138 gm., the mean being 0.0896 gm. The value used to compute the blood volume in the 6 determinations given in Table I was 0.09 gm.

The larva of *Galleria mellonella* was handled in much the same manner but because of its smaller size greater care was necessary to insure complete removal of the blood. The total solids per c.c. of the blood varied in 8 determinations made on volumes of 0.02 c.c. to 0.1 c.c. from 0.0732 gm. to 0.1850 gm., the mean being 0.1242 gm. The value 0.12 gm. was used to calculate the blood volume. The instars of the larvæ used were not ascertained.

The agreement of the mean values obtained by the two methods for *Bombyx mori* is good and indicates that the blood volume in c.c. of the silkworm in the late instars is equal to about 30 per cent of the body weight. The blood volume of *Galleria mellonella* calculated in the same way is about 41 per cent of the body weight.

Nazari[4] found that the weight of the blood of the silkworm was equal to about one-fifth of the weight of the larva. He

[4]Nazari, A. Atti della R. Accademia dei Georgefili. Firenzi (IV ser.) Anno 25, vol. 80, pp. 356–363. 1902.

removed the blood by cutting off the posterior dorsal horn and by making incisions in the prolegs. On the basis of his determinations, the blood volume would be 18.1 per cent, a value considerably below any obtained in this study except when the removal of the blood was known to be incomplete. Landois[5] found that the ratio of the weight of insect larvæ to the weight of the blood is 4:1, and cites the larva of the moth *Macrothylacia* (*Gastropacha*) *rubi* L. as an example in which this ratio has been observed. Assuming the specific gravity of the blood to lie between 1.01 and 1.04 the blood volume would be 24+ per cent. A simple bleeding method was apparently used, and complete removal of the blood was probably not attained. Bishop[6] states that the blood of the honeybee larva (worker) comprises 25 to 30 per cent of the body weight. Presumably his figures refer to per cent of the blood by weight to the total body weight. Using his value of 1.045 for the specific gravity of the blood, the blood volume in c.c. would lie within the limits of 23.9 and 28.7 per cent of the total weight. The method of determining the weight is not given, but the agreement with the figures given above for the blood volume of the silkworm is good. Haber[8] finds that the adult cockroach (*Blattella germica* L.) contains about 68 per cent of body moisture of which he assumes one-third or about 20 per cent to be blood. He states that the moistness of the tissues is due to a serum which doubtless is derived from the blood plasma. For this reason it is difficult to learn the exact blood volume of an insect. The methods described above are at best only approximations of the true blood volume but as approximations they may be useful in several ways.

The quantity of water in the silkworm of the fifth instar has been shown by Kellner[7] to be about 80 per cent by weight. Adopting 30 c.c. per 100 gm. of larvæ as the approximate blood volume, the per cent of the blood by weight will be about 31.2 of which 28.4 per cent is water, leaving 51.6 per cent by weight of water bound in the tissues.

The methods described herein have been tested only on immature insects. It is known that the blood volume of certain immature insects is larger than that of adult

[5]Landois, H. Zeitschr. f. wiss. Zool. vol. 14, pp. 55–70, 1864.
[6]Bishop, G. H. Jour. Biol. Chem. Vol. 58, pp. 543–565, 1923–24.
[8]Haber, V. R. Bull. Brooklyn Ent. Soc. vol. 21, No. 3, pp. 61–100. 1926.
[7]Kellner, O. Die landwirthschaftlichen Versuchs-Stationen, vol. 30, pp. 59–86. 1884.

individuals[5],[8]. Mature forms of many insects have elongated appendages and body structures which can probably be drained of blood only with great difficulty. For such insects one of the indicator methods which have been used on vertebrate animals might be adopted.

AN ERGATANDROUS FORM IN PONERA OPACICEPS MAYR.*

M. R. Smith and G. W. Haug,
A. and M. College, Mississippi.

This description is based on two specimens which were collected by the junior author on August 25, 1930, from a colony of *Ponera opaciceps* Mayr, beneath the bark of a pine tree at Landon, Mississippi. That the specimens are not callow workers, as first supposed by the junior author from a superficial examination of them in the field, is clearly indicated by their 13-segmented antennae, the general shape of their bodies, and the prominent genital appendages at the apex of their gasters.

Ponera opaciceps Mayr.

Ponera opaciceps Mayr, Verh. Zool.-bot. Ges. Wien, Vol. 37, p. 536 (1887), worker and female.

Ponera opaciceps M. R. Smith, Annals Ent. Soc. Amer., Vol. 22, p. 545 (1929), male.

Ergataner: (Plate I., Figures 2 and 3). Length of head .68–.76 mm; length of thorax .935–.965 mm.

Head, including mandibles, longer than broad; posterior border almost straight, and sides subparallel, thus giving the head a more rectangular appearance than with the worker. Mandibles moderately broad, triangular, edentate stubs. Clypeus strongly convex, protuberant. Antennae 13-segmented, gradually but not strongly enlarging distally; scapes short, subcylindrical, approximately equal in length to the second, third, and fourth segments of funiculi taken together. Compound eyes small, almost circular, separated from the base of the mandibles by a space equivalent to approximately one and one-half times their greatest diameter. Thorax short, robust; viewed laterally the pro-mesonotal and meso-epinotal sutures are very distinct, especially

*Contribution from the Mississippi Agricultural Experiment Station.

on the dorsum; mesonotum strongly gibbous, clearly projecting above the general surface of the pronotum and epinotum. Between the mesonotum and epinotum the suture is represented by a very strong constriction, following which the epinotum forms a rather long and gentle arch terminating at the petiole. The basal surface and declivity of the epinotum merge into each other so gradually that they are hardly distinguishable. Petiole large, robust, anterior and posterior faces convex, superior border rounded. Gaster similar to that of the worker, but bearing prominent genital appendages.

Color sordid yellow; margins of compound eyes and antennal cavities black, articulation of legs and sutures of thorax brown.

Ponera opaciceps Mayr is without doubt the most common species of *Ponera* in the southern part of Mississippi. Farther north in the state it is replaced by *Ponera trigona* var. *opacior* Forel and by *Ponera coarctata* subsp. *pennsylvanica* Buckley. In the Americas it ranges from Brazil and Uruguay to at least as far north as Texas and Mississippi. Although the worker and female were described by Mayr in 1887, and the ants have been taken on numerous occasions since, this is the first time that anyone has observed ergataners as far as we are aware. Ergataners have been found to occur in several other species of *Ponera*, namely: *P. eduardi* Forel, *P. punctatissima* Roger, and *P. ergatandria* Forel. It is therefore not surprising that *P. opaciceps* should have this peculiar worker male-like form. Of the species here mentioned, *P. ergatandria* was the only form in this country previously known to have ergataners.

The writers greatly regret that the two specimens on which this description is based are apparently immature as is evidenced by their extremely pale color, and by the fact that their body wall shrank considerably when the specimens were taken from alcohol and mounted. In shipping, the gaster of each was detached and lost, hence it is not figured here. The authors studied both gasters before they were lost, and are positive that each bore prominent male genitalia at their apex.

EXPLANATION OF PLATE.

Ponera opaciceps Mayr.

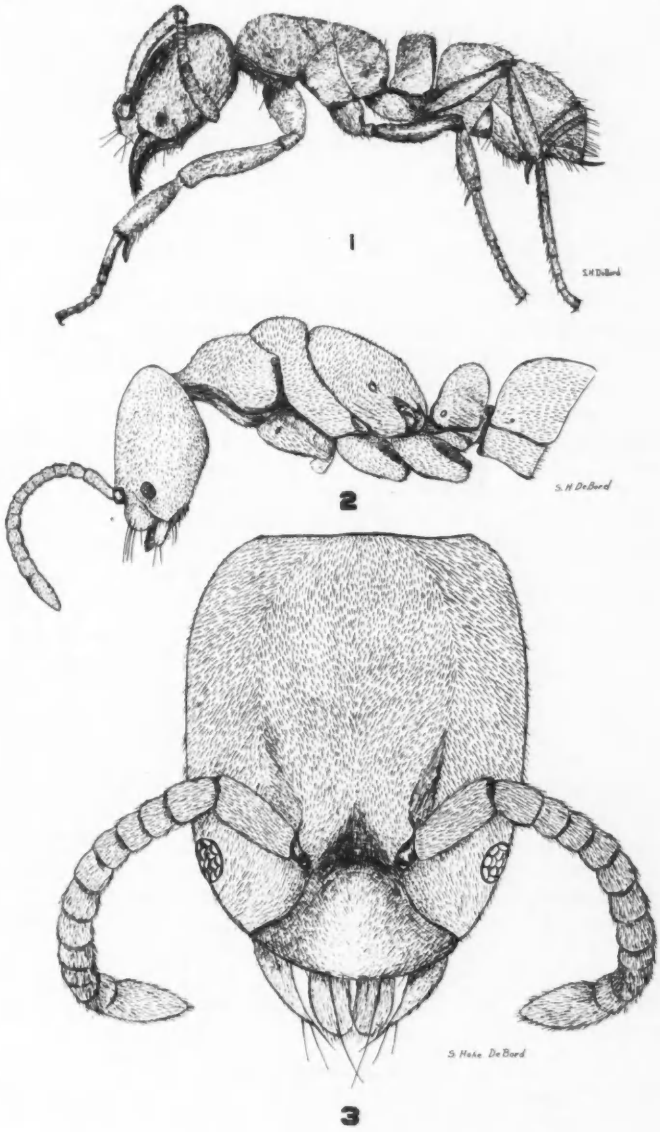
Fig. 1. Lateral view of worker.

Fig. 2. Lateral view of ergataner showing head, thorax, petiole and base of gaster.

Fig. 3. Front view of head of ergataner.

Ergataner of Ponera Opaciceps Mayr
M. R. Smith and G. W. Haug

PLATE I.



THE CORNELL UNIVERSITY ENTOMOLOGICAL EXPEDITION TO SOUTH AMERICA, 1919 AND 1920, SCIENTIFIC RESULTS, NUMBER 5, HEMIPTERA-TINGITIDÆ.

CARL J. DRAKE,
Ames, Iowa.

Through the courtesy of Dr. J. Chester Bradley, the writer has been permitted to study the Tingitidæ collected by the Cornell Expedition in South America. This collection is represented by twenty-two species, four of which are described below as new. The types are deposited in the collection of Cornell University, Ithaca, New York. Unless otherwise noted under the species, the specimens were collected by Dr. Bradley.

Monanthia monotropidia Stål.

Lassance, Minas Geraes, Brazil, 1 female.

Monanthia parmata Distant.

Posadas Misiones, Argentina, January 16–24, 1920, 1 male and 3 females.

Monanthia figurata Drake.

Lassance, Minas Geraes, Brazil, November 9–19, 1916, 1 female.

Teleonemia sacchari Fabricius.

Belle Horizonte, Minas Geraes, Brazil, November 1–6, 1919, 1 male.

Teleonemia prolixa Stål.

Diamantina, Minas Geraes, Brazil, November 14–18, 1919, 1 male; Lima, Peru, May 16, 1920, 1 female.

Teleonemia scrupulosa Stål.

Aquicauana, Matta Grossa, Brazil, December 11–13, 1913, 1 male.

Tigava pracellens Stål.

Bello Horizonte, Minas Geraes, Brazil, November 1–6, 1919, 1 male.

Tingis americana Drake.

Lassance, Minas Geraes, Brazil, November 14, 1919, R. G. Harris, collector, 1 female.

Acanthocheila kahavala Kirkaldy.

El Campamiento, Col. Perené, Peru, June, 1920, 1 female.

Leptocysta sex-nebulosa Stål.

Aracataca, Magdalena, Colombia, August 2, 1920, 1 female.

Leptobyrsa mendecina Pennington.

Ptrerillos, Mendcina, Argentina, altitude, 4,000 feet, March 16–20, 1920, 53 specimens.

Leptobyrsa elegantula Drake.

Rio de Janeiro, October 30, 1919, a male; El Campamiento, Col. Perené, Peru, June 18, 1920, 1 male.

Leptopharsa magnifica Drake.

Lassance, Minas Geraes, Brazil, November 9–19, 1919, 1 female.

Leptodictya dohrni Stål.

Tambo Eneñas, Cam. del Pichis, Peru, July 4, 1920, 7 specimens.

Leptodictya madelinæ Drake.

Tambo Eneñas, Cam. del Pichis, Peru, July 4, 1920, 13 specimens. The discoidal area is considerably broader in the female than in the male; the number of confused rows of areolae varying from four to six in the male and from six to nine in the female. The nervelets of the areolae (two at base and increasing to five or six at apex) along the outer margins of the costal area are dark fuscous, the marginal row of areolae being clouded with fuscous. The nervures of the distal half of the elytra are also very dark fuscous.

Leptodictya grandatis, n. sp.

Differs from *madelinæ* in having five long sharp spines on the head, narrower and more widely reticulated costal area. Discoidal area narrower, with four to six areolae at its widest part. Costal area with one row of clouded areolae along outer margin, the nervelets along the margin and distal portion black-fuscous. In *madelinæ* the dark area along the outer

margin wider and, also, more of the nervelets along the outer margin and in the distal half of the elytra black-fuscous.

Head black, with five long slender black-tipped spines. Antennae long, slender, brownish black; segment I about two and a half times as long as two; III three times as long as four; I and II black. Rostrum extending to end of sulcus; rostral laminae strongly developed. Pronotum moderately swollen, coarsely pitted, tricarinate; lateral carinae parallel, foliaceous, each uniseriate; median carinae more strongly elevated, especially anteriorly, mostly uniseriate, biseriate in front. Paranota completely reflexed, resting on sides of pronotum, biseriate above and triseriate below. Hood moderately large, narrow, projecting over basal portion of head. Hood, paranota and carinae testaceous, the areolae translucent.

Elytra rather broad, testaceous, the nervures separating areas and along the outer margins, nervelets of subcostal, most of sutural, some of discoidal, and near outer margin and portion of costal area black-fuscous; areolae somewhat confused and slightly variable in size, except row along outer margin of costal area clouded with fuscous; subcostal area biseriate, vertical; discoidal area with an oblique, fuscous nervure; costal area broad, with three oblique, depressed, slightly enlarged nervures, the outer row of areolae partly or entirely clouded with fuscous, more coarsely reticulated along the subcostal area than in *madelinæ*. Male claspers long, strongly curved, very thick at the base.

Length, 4.85 mm.; width, 2.12 mm.

Tambo Eneñas, Cam. del Pichis, Peru, July 4, 1920, 5 specimens; ***holotype***, male, (Cornell U., No. 1016.1) and ***allotype***, female, (Cornell U., No. 1016.2). In *L. williamsi* Drake the hood is much more compressed and narrower, the spine blunt, and without clouded areolae along the outer margin of costal area.

Gargaphia subpilosa Berg.

Potrerillos, Mendocina, Argentina, March 16–20, 1920, altitude, 4,000 feet; many specimens; Tigre, Buenos Aires, February 8, 1920, 1 male; Urucum, Corumbá, Brazil, 1 male. A photograph of Berg's type enables the writer to determine this species.

Gargaphia torresi Costa Lima.

Corumbá, Matta Grossa, December 14–23, 1919, and Lassance, Minas Geraes, Brazil, several specimens. This species feeds and breeds on cotton in Brazil. Its wild host plants are unknown.

Dicysta braziliensis Drake.

Upper River, Pachitea, Peru, July 21, 1920, 1 female.

Leptobyrsa bradleyi, n. sp.

Moderately elongate, rather broad, testaceous, the reticulations with a few dark fuscous spots, the areolae hyaline. Head short, brown, with three very long slender testaceous spines, the anterior pair much shorter and curved inwardly. Rostrum reaching to the intermediate coxae; rostral laminae rather widely separated on metasternum, cordiform. Bucculae contiguous in front. Hood small, compressed, faintly produced in front. Paranota rather broad, somewhat rounded, strongly reflexed, mostly quadriseriate, the areolae hyaline and moderately large. Pronotum strongly narrowed anteriorly, somewhat embrowned, distinctly punctate, tricarinate, each composed of a single row of areolae; lateral carinae slightly constricted beyond the middle and, also, slightly converging behind.

Elytra widening posteriorly, their tips separated, costal area broad, the areolae rather large and slightly confused in arrangement, with four cells at its widest part; subcostal area moderately broad, with three rows of rather small areolae; discoidal long, narrow at both base and apex, widest behind the middle, considerably impressed, finely reticulated, with six or seven cells at its widest part, bounded by strongly raised veins. Margins of elytra clothed with long fine hairs; hairs on reticulations fine and rather sparse. Legs testaceous, the tarsi brown. Antennae testaceous, pilose, the apical segment almost entirely black. Body beneath pale brown. Wings clear, a little longer than the abdomen.

Length, 3.92 mm.; width, 2.12 mm.

Holotype, male (Cornell U. No. 1017.1) and *allotype*, female (Cornell U. No. 1017.2), Matucana, Peru, May 27, 1930; 6 paratypes—two taken with type, two from Huacapistana, Rio Tarma, and two from Huacapistana, Rio Tarma, June 1–3, 1921, Peru. This tingitid is named in honor of Dr. J. Chester Bradley, who has taken a very keen and active interest in South American insects. The species is very distinct and not easily confused with other members of the genus.

Gargaphia opima, n. sp.

Moderately elongate, rather narrow, about the size of *G. lasciva* Gibson, but with a smaller hood, broader and differently marked costal area. Antennae long, slender, pilose; segment I rather long, two and a half times as long as two, dark brown to almost black; II short, slender, dark brown to black; III long, brown; IV long, brownish black. Rostrum reaching to the middle of the mesosternum. Body beneath blackish. Legs brown, the tarsi darker.

Pronotum black, tumid, finely pitted; hood small, faintly produced in front, compressed; paranota entirely biseriate, strongly reflexed, the outer margin rounded. Carinae foliaceous, uniseriate, brown, the areolae moderately large; lateral carinae parallel, extending as far

anteriorly as base of hood, but rather widely separated from it; median carina not more strongly raised. Elytra with nervures in apical portion, discoidal area, basal portion of subcostal area, two or three slightly enlarged oblique nervures in costal area and marginal nervure fuscous-black the areolae hyaline; costal area moderately broad, with four areolae at base and five at widest part, the areolae somewhat confused and moderately large; subcostal area biseriate; discoidal area rather short, widest beyond middle, rather closely reticulated, with five or six cells at its widest part; wings slightly longer than abdomen.

Length, 3.51 mm.; width, 1.38 mm.

Holotype, male (Cornell U. No. 1018.1) and *allotype*, female (Cornell U. No. 1018.2), Miriatiriani, Cam. del Pichis, Peru, July 9, 1920; 3 paratypes, taken with type.

Gargaphia decoris, n. sp.

Elongate, broad, testaceous, the pronotum brown, the elytra with three to five transverse nervures in costal area (tending to form a transverse band) and an elongate spot on outer boundary of discoidal area dark fuscous. Head brownish, with five rather long slender spines. Rostrum extending almost to the transverse laminae. Antennae long, slender, pilose, brownish; the last segment (except basal portion) fuscous black; segment I stout, rather long, three times as long as two, the latter short and much more slender; III very long, two and a half times as long as four.

Pronotum considerably swollen, closely pitted, reticulate behind; hood small, strongly compressed, almost sub-truncate in front. Paranota rather broad, strongly reflexed, almost erect, mostly triseriate, quadriseriate opposite humeri, rather widely reticulated. Elytra broad, broadly rounded behind, the tips not widely separated; costal area very broad, the areolae rather large, not regularly arranged in rows, and about six deep at widest part; discoidal area broader in female than male, closely reticulated, rather short, broadly rounded at apex, widest beyond the middle. Legs brownish, the tarsi dark fuscous. Areolae hyaline. Body beneath brownish black.

Length, 5.12 mm.; width, 2.66 mm.

Holotype, male (Cornell U. No. 1019.1) and *allotype*, female (Cornell U. No. 1019.2), Bello Horizonte, Minas Geraes, Brazil, November 1–5, 1916. Paratypes, 20 specimens, taken with type. Closely allied to *G. obliqua* Stål, but differing in the more strongly constricted lateral carinae, shorter discoidal area, and differently marked elytra. The carinae are considerably raised, uniseriate, rather thick; the transverse fascia of costal area formed by the black-fuscous nervures, the areolae being hyaline.

AN ADDITIONAL NOTE ON THE BEHAVIOR OF HIBERNATING POLISTES WASPS.

PHIL RAU,
Kirkwood, Mo.

A recent paper* tells how hibernating Polistes wasps, after spending the winter in shelter away from the nest, visit the home at intervals, whenever the temperature is favorable, and finally return in the spring to the old home site, and from there and not from their place of hibernation do they disseminate and found colonies of their own.

There is nothing in the paper, however, to show what their behavior is during the early part of the fall when they are first taking leave from the nest. A few fortunate observations this year reveal what happens in the lives of the wasps during this significant interval when their interest in nesting has ceased and their attention is turning gradually to their winter welfare.

My first inkling that fraternizing increases at the end of the season was gained on August 27, 1930†, when I noticed that an orphan‡ nest which normally had only three adults, suddenly at noon harbored twelve wasps, all workers or queens, which had come to the nest from unknown sources. Another nest near by (not an orphan one) had ten workers, its normal population, on this date.

Two weeks later, September 11, these 22 adults on both nests had dispersed, but ten wasps were huddled in a crack between two ceiling boards of the shed, four and eight feet distant from the two abandoned nests. This crack was four feet long, and there was ample space where the ten could have spread themselves out if they had so desired, but they were piled one atop the other in a compact mass, so that the bodies of some were hanging out in full view.

This observation shows for *P. pallipes*, as I have already shown for *P. annularis*, and *P. rubigenosis*, that gregariousness

*Rau, "The Behavior of Hibernating *Polistes* Wasps." Ann. Ent. Soc. Amer. *23:* 461–466. 1930.

†The unusual drought caused dissemination earlier than usual that year.

‡Orphan nests are those nests in which the queens have been lost, or removed in an experiment, and the management of the nest, even to the laying of infertile eggs, devolves upon the orphan workers.

is a factor in their hibernation. The most interesting and perplexing point, from the standpoint of psychology, is the fact that, even though the temperature is still high enough for comfort, they prepare for hibernation.* But this location afforded only temporary shelter, and as the season advanced they dispersed to other quarters, as follows.

Two days later, September 13, they were still in the crack, but in the afternoon two of them broke away from the crowd and walked a few inches away, where they found another hiding-place further up in the same crack. The others had extricated themselves from the group and ranged in single file, with heads deep in the crack and tails protruding. The next day at 10:00 A. M., the two groups were in the same places and positions, excepting that two more wasps had deserted the large group, and behold! they had again taken up residence on the nest! As in *P. annularis*, these visits strengthen their memory of the old home, so that when they wake from their winter's sleep elsewhere, they return to it and found the new colonies near the site.

At 2 P. M., it became very dark, preceding a storm, when in my presence one of the two left the nest and joined the company in the crack. The remaining one declined to follow the crowd; she asserted her independence by persistently clinging to the old, empty nest, and on September 16 she was still there, huddling behind the comb. That night it rained and the temperature fell; the following day I found the group crouching deeper in the crack, and whereas previously they had rested in single file with the abdomens protruding to the wind, they now had pulled in their tails after them and assumed their old position, one atop the other, to get in out of the cold and conserve body warmth.

On September 15, there was a drop in temperature after the rain, and with that it became apparent that this crack was probably only a temporary hibernating spot, because the next morning three had disappeared. Another cold night followed, with a minimum of 60° F., followed by a warmer afternoon when the mercury rose for a while to 85°. I came home that evening expecting to find that they had sought more secure quarters, for I knew that they would not be able to survive the

*This habit of clustering and remaining immovable on the chilly days was noticed among wasps seen at large and also those kept in cages.

winter in that poor protection. True to my expectations, they had gone; the exodus had taken place some time during the day, when the temperature was higher. In other words, a period of generally cooler weather had aroused in the wasps an inclination to come together, even from different nests, and seek to satisfy their immediate needs for protection in some place near the nest. But a nip of real cold had convinced them that they must escape to safe quarters before cold should benumb them and preclude activity; in this case they had availed themselves of the warm afternoon following the night of 60°. This combination of temperatures supplied ideal conditions for the beginning of true hibernation; the 60° would convince the wasps of the need of seeking shelter, and the higher temperature for a few hours, while the chill was fresh in their minds, would give them the opportunity to move before too late. I think that we should be able to find out experimentally the various optimums of temperature for each stage in the hibernating period.

These few observations show mainly that the wasps do not, as by a date on the calendar, dig themselves in for the winter, but gradually, with misgivings and frequent displays of behavioristic adaptations, they adjust their activities to the new conditions. In this prolonged exile, which is a large event in the lives of these queens (they probably are queens), memory of the home region is, as I said before, a large factor in the selection of a site for the founding of the new colony.

With the prehibernating behavior of *P. pallipes* in mind, I can now appreciate the observation of the prehibernation of *P. annularis* on September 12, 1930, as observed at Old Mines, Missouri. Here a nest of *P. annularis* was attached to a post near a stream. A thorough search in the vicinity revealed only this one nest. The cells were all empty, but about twenty adult females (presumably queens) still clung to it. They were idle and listless; it seemed to me that they were ready to disperse and hibernate, if indeed some of the colony had not already done so. A search nearby under bark and stones revealed none. Fortune favored me, however, for in two knotholes or cavities in two fence posts nearby I discovered groups of wasps which, I supposed, had come from this nest. One hole harbored fifteen wasps, the other ten, huddled in these inadequate shelters. The afternoon warmth was inviting, and

the wasps of both lots were ready to fly in the sunshine when I attempted to take them. Some of them, when disturbed, spat out enormous drops of glistening water. Both posts were less than twenty feet from the nest, and in the light of my observations on *P. pallipes* I can only assume that these wasps had come from this nest, and had taken up temporary hibernation nearby before making the choice of final quarters. These *P. annularis* again showed gregariousness, and it appears, since there were no other nests in the vicinity, that the sisters keep together over the winter. It is possible, also, that when I discovered the twenty on the nest, they were only in the act of revisiting their former home from their temporary abode.

On September 14, at Allenton, Missouri, I found in two empty wren-houses ten and twelve *P. annularis*, apparently seeking this type of shelter. Their nests were not in the bird houses but they came to them in mid-afternoon, when the sunshine was warm.

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ON THE ANATOMY OF GRYLLOBLATTA CAMPODEIFORMIS WALKER.

1. Exoskeleton and Musculature of the Head.

E. M. Walker,
Department of Biology, University of Toronto.

This is the first of a series of papers on the anatomy of the primitive Orthopteran *Grylloblatta campodeiformis* Walk., which it is hoped may be ready for publication from time to time within the next few years. The present contribution deals with Grylloblatta only, comparisons with other Orthopteroid insects being reserved for the next paper of the series.

The observations recorded were made almost exclusively from dissections of adult specimens preserved in 70% alcohol and potash preparations. Serial sections were made from three specimens but were of little assistance in the study of either chitinous structures or musculature. As the material was limited unusual care was taken in the dissections. All the muscles recorded were observed at least twice.

EXOSKELETON OF THE HEAD.

The Head Capsule. In general form and position the head of *Grylloblatta* is very like that of an earwig (e.g., *Forficula* or *Anisolabis*), being flattened and prognathous and usually held almost horizontally. The positions of the antennæ and compound eyes are also similar to those of the Dermaptera. The surface is smooth, with a clothing of short setæ, which are for the most part scanty but are abundant on the antennæ and palpi. Those of the antennæ are fine, short and uniform, those of the palpi longer and less uniform in length.

The head capsule (Pl. I, 1–3), exclusive of the clypeus, is about as broad as long, well rounded behind and laterally and truncated in front. The *antennal sockets* (Figs. 1, 3–5, *as*) are situated immediately behind the mandibular articulation and laterad of the epistomal suture. Each socket is subcircular, with an antero-internal angle, and is surrounded by a thickened and somewhat elevated rim, which bears a small ventral projection or *antennifer* (Figs. 3, 4, *af*), upon which the antenna is pivoted.

The *compound eyes* (Figs. 1–5) are somewhat smaller than the antennal sockets, situated laterally at a distance of about their own longitudinal diameter from the base of the mandible and about half that distance from the outer rim of the antennal socket. They are

black-pigmented and composed of about sixty rounded facets, separate from one another and arranged in slightly irregular rows. Around each eye is a slightly thickened rim, best developed antero-dorsally, where the heavier cuticle is continuous with that of the rim of the antennal socket.

The *epistomal* (fronto-clypeal) *suture* (Figs. 1, 4, *es*) is distinct and marks the position of a broad, low, internal ridge (Figs. 2, 5), which is continuous on each side with the anterior arm of the tentorium and the dorsal articulation of the mandible.

The *anterior tentorial pits* (Fig. 4, *ap*) are continuous with the epistomal suture at the antero-ventral edge of the rim of the antennal socket.

The *clypeus* (Fig. 1, *cl*) is large, rounded in front, and distinctly divided into a proximal, well-sclerotized postclypeus, and a distal, more membranous and somewhat larger anteclypeus. As seen in potash preparations these parts are clearly marked but not separated externally by a suture.

At the base of the clypeus, on each side, is the *dorsal articulation of the mandible* (Fig. 3, *dm*), a ginglymus joint consisting of (1) a small rounded convexity just in front of the antennal socket, and (2) mesad of this, a small concavity at the basal angle of the clypeus. Both of these parts are more heavily sclerotized than the neighbouring cuticular areas. Extending from the ventro-lateral margin of the antennal socket, downwards and forwards, and around to the ventral surface, terminating at the ventral articulation of the mandible, is the *subgenal suture* (Figs. 1, 3, 4, *sg*), which separates from the gena the so-called "trochantine of the mandible." It marks the position of a strong internal ridge (Fig. 5, *sg*), which joins the postero-ventral margin of the anterior arm of the tentorium.

From the dorsal portion of the ocular rim a well-marked suture (Figs. 1, 3, *ps*) and internal ridge extends backwards and slightly inwards to the postero-lateral angle of the occipital foramen. These ridges form a pair of arches which give strength to the otherwise somewhat thinly sclerotized head capsule, connecting, as they do, the firm areas at the base of the mandibles and about the eyes and base of the antennæ with the thickened rim of the occipital foramen, the tentorium forming the brace which connects these parts ventrally. These sutures, which may be called the *parietal sutures*, divide the dorsal and lateral regions of the head capsule, behind the eyes, into median and lateral areas.

In the median area can be seen the primitive *epicranial suture* (Fig. 1, *ec*), which is distinct in the adult insect, although less conspicuous than in the earlier stages. It is indicated by lines of thinner cuticle than elsewhere, there being no corresponding internal ridges. The stem of the suture (*coronal suture* of Snodgrass), extends from the occipital foramen to a point a little behind the eyes. The *frontal sutures*, or arms of the epicranial suture, diverge widely, terminating near the hind margins of the antennal sockets, where they are met by the dorsal arms of the tentorium.

The lateral areas of the epicranium are continued forward below the eyes to the subgenal sutures and include the gena. They are bounded ventrally by the *occipital sutures* (Fig. 2, *oc.*), which are well marked but incomplete posteriorly, extending from the mandibular articulation, where they are continuous with the subgenal suture, to a point about opposite the middle of the occipital foramen.

The *gena*, as defined by Snodgrass, is the "parietal area behind and below the eyes." This definition is based upon insects with vertically placed mouth-parts, such as a typical locust. As applied to a prognathous insect like *Grylloblatta*, the words "behind and below" must be changed to *below and before*. According to this definition the gena of *Grylloblatta* is a very small area, being merely that part of the lateral surface of the head which lies in front of the eyes and behind the subgenal suture.

The ventral and postero-ventral region of the head capsule, nearly surrounding the occipital foramen, is the occipital region. It is not defined dorsally, where it is continuous with the parietal areas, but it is bounded laterally by the occipital sutures.

The *postoccipital suture* (Fig. 2, *poc*) is distinct but the postoccipital rim is extremely narrow. Antero-ventrally the sutures curve out below to terminate in the *posterior tentorial pits* (Fig. 2, *pp*). These are narrow, oblique, flattened pits, somewhat elongated posteriorly in common with the general elongation of parts in this region.

The *occipital foramen* is large, elongate quadrangular, narrowing evenly from the hind margin forward. Anteriorly it occupies a horizontal plane but posteriorly it is curved dorsad, so as to face postero-ventrad. On each side of the foramen, about midway of its length is a small condyle (Fig. 2, *cv*) for the articulation of the lateral cervical sclerites.

The main part of the *occipital region*, comprising *occiput* and *postgena* is not definitely divided into these areas. In contrast to the gena and in correlation with the forward position of the mouth-parts, the postgena, or that part of it in front of the occipital foramen, is elongated, so that the articulation of the mandibles lies far anterior to that of the maxillæ.

The ventral articulation of the mandible (Figs. 2, 5, *vm*) consists of a small socket at the anterior end of the postgena, bounded above by the projecting end of the subgenal ridge. Into this socket fits the mandibular condyle.

At the point of articulation of the cardo of the maxillæ there is a slight prominence (Fig. 2, *mxc*) of the ventral margin of the head capsule at the outer extremity of its junction with the posterior arms of the tentorium.

The tentorium is very like that of *Forficula*. The body (Fig. 2, *t*), which includes the frontal plate ("laminatentorium" of McGillivray), is relatively narrow and flat in its posterior half, except where it curves downward behind at its junction with the posterior arms. Anteriorly it is expanded and dorsally concave where it meets the anterior and dorsal arms. The *anterior arms* (Figs. 2, 4, 5, 23, 27, *at*) are triangular,

with the base arising just below the antennary sockets and the somewhat twisted apices converging to join the body of the tentorium. The inner or anterior side is continuous with the epistomal ridge and the outer or posterior side with the subgenal ridge. The *dorsal arms* (Figs. 2, 26, 28, *dt*) arise from the dorso-lateral edges of the body of the tentorium, just behind the anterior arms. They are broadest at base but taper as they pass upward, so that they are very slender near their tips but are suddenly expanded just before they join the roof of the head capsule at the outer ends of the frontal sutures. The *posterior arms* (Fig. 2, *pt*) are short, broadly triangular and strongly divergent, so that their anterior margins are transverse. They pass downward and outward to the basal articulation of the maxillæ. On the ventro-anterior margin of each arm, just mesad of the articulation of the maxilla, is a small tubercle for the attachment of the median retractor muscle of the labium (Fig. 2, *lt*).

APPENDAGES OF THE HEAD.

The *antennæ* (Figs. 20, 21) are a little longer than the head and first two thoracic segments together and are composed of 28 or 29 segments. The first segment or scape is much the largest. It is somewhat less than twice as long as its middle diameter, subcylindrical but slightly constricted in the middle, and largest near the distal end. It swings upon a pivot formed by the antennifer, a small ventral projection from the rim of the antennal socket (Figs. 3, 4, *af*). The second segment or pedicel is half as long as the scape and a little longer than broad. The scape and pedicel bear only a few bristles but the remaining segments, forming the flagellum, are fairly densely and uniformly covered with short hairs which become gradually finer on the distal segments. The segments of the flagellum are cylindrical, most of them somewhat enlarged distally and rounded at apex. They are of fairly equal diameter in the proximal half or less of the antenna, but distally they diminish in thickness and the constrictions between the segments become much more marked, in consequence of which the terminal segments break off readily.

The *labrum* (Fig. 1, *lr*) is a rounded flap, about as broad as long, constricted at its base, where it joins the clypeus. Its upper surface is moderately sclerotized, the dark brown spot on each lateral margin not being specially hardened. Slender hairs of moderate length are thinly and rather evenly distributed over the surface. The lower or epipharyngeal surface (Fig. 2) is membranous except at the outer or basal corners, where there is a small sclerite, the *torma* (Fig. 2, *tm*), bearing a dorsal tubercle, and from which two small bars pass backwards and inwards in the epipharyngeal wall of the clypeal region. The epipharyngeal surface of the labrum bears two longitudinal groups of very short setæ, parallel with the lateral margins. The epipharyngeal surface of the clypeus seems to be devoid of hairs.

The *hypopharynx* (Figs. 6, 7, 8, 16, 28, 29, *hy*) is a broadly oval, somewhat flattened lobe, slightly narrowed toward the base. The

broader distal portion is flexible but bears no hairy, membranous, sensory area, such as usually occurs in orthopteroid insects. Its cuticle is thinly sclerotized, more firmly so along the lateral margins, where a pair of ill-defined lateral bars may be distinguished. The narrower proximal part of the hypopharynx is supported ventrally by a V-shaped sclerite (Fig. 7, *hv*), the apex of which lies in the labio-hypopharyngeal angle and bears the small, crescentic opening of the salivary duct (Fig. 7, *sd*), no salivary cup being present. The arms of the V-shaped sclerite are distally expanded and are continuous, at the lateral margins, with the suspensorial bars (Figs. 6, 8, *hs*). These are a pair of broadly triangular plates, whose apices meet in the middle line, at about the proximal third, to form a narrow bridge, completing with the ventral sclerite a girdle for the support of the base of the hypopharynx. Each suspensorial bar bears at its basal angle two branches, an *oral* and a *mandibular*. The oral branch (Figs. 6, 8, 29, 30, *hso*) is a more or less upright, slender bar on each side of the mouth opening and connected with the pharyngeal wall, on which it is somewhat expanded. The mandibular branch (Figs. 6, 8, 29, 30, *hsm*) is much thicker and strongly curved. It lies more horizontally, just below the mouth opening, and its distal end comes into close relation with the inner basal angle of the mandible.

The *mandibles* (Figs. 9–16) are large and heavily sclerotized, especially at the apices and along the mesal margins, where they are deeply pigmented. They are slightly convex above and concave below, the apices curving inward and slightly downward. Each mandible has a proximal tooth a little before the middle of the inner margin, and a pair of distal teeth, the larger of which is apical, the smaller subapical. Except where interrupted by the proximal tooth the inner margin has a cutting edge along its entire length, the proximal and distal parts of which meet at a broadly obtuse angle. There is no indication of a molar surface.

The subapical tooth of the right mandible (Fig. 11) is entirely marginal but that of the left (Fig. 12) is continued a short distance on the ventral surface in the form of an oblique ridge. Between the ridge and the apical tooth there is a slight furrow into which the apical tooth of the right mandible appears to fit when the jaws are closed. The proximal tooth of the right mandible is single and but slightly notched, while that of the left mandible is distinctly notched and there is another smaller tooth just behind it, the notch between the two possibly serving as a socket for the reception of the proximal tooth of the right mandible when the jaws are closed.

The dorsal articular surface (Fig. 9, dm^1), like the corresponding surface of the head capsule (Fig. 3, 5, *dm*) is concavo-convex, the concavity being laterad of the convexity, which is a small but prominent process fitting into the hollow at the outer basal angle of the clypeus. The ventral condyle (Fig. 11, *mc*) is a prominent rounded knob a little nearer the outer margin than is the dorsal articulation.

The mandibles bear a few moderate-sized setæ on the convex surface and a very few much smaller ones on the concave surface.

The *maxillæ* (Figs. 17, 18) are large, projecting slightly beyond the tips of the mandibles, and typically orthopteroid in structure.

The *cardo* (*cd*) and *stipes* (*st*) show the usual division into lateral and mesial areas due to the presence of a strong internal ridge (*str*), which gives support to the parts concerned and to some extent serves for muscular attachment. The suture dividing the cardo (*cdr*) is curved and subparallel to the mesial margin. It reaches the lateral margin just distal to the *basal arm* (*cda*), to which the abductor muscle is attached. The basal arm is well developed and projects inward over a slight concavity in the margin of the head capsule. Just mesad of the arm the cardo bears a very minute marginal prominence representing the articular condyle. It fits against the edge of the head capsule, which is slightly raised at this point. The cardo is bounded laterally by a distinct ridge connected below with the basal arm.

The ridge of the stipes divides the latter rather near the mesial margin, as in the Orthoptera, the outer part being broad and extending well over to the dorsal surface. There is no indication of a palpifer.

The terminal lobes are rather slender and strongly curved, very like those of an earwig in form, and their tips are practically coincident. The proximal segment of the *galea* (subgalea, *sgl*) is short and does not appear distinctly in ventral view, but is seen in a lateral or dorsal view. It terminates distally in a marked dorsal prominence, which is readily seen in profile. The distal segment of the galea (*g*) is strongly arcuate, flat and falciform, with a small rounded apex. On its concave edge near the apex is a slight convexity (Fig. 34), separated from the apex by a slight notch. This convexity bears numerous small hairs, which are doubtless sensory.

The *lacinia* (*l*) is curved similarly to the galea and is well sclerotized and deeply pigmented. Its inner margin is concave throughout its entire length, except at base where it bears a prominent tooth. There is also a small ante-apical tooth some distance before the sharp apex. Along the concave edge, between the two teeth, is a row of about fifteen fairly stiff bristles.

The *maxillary palpi* (*mxp*) are of moderate length, the segments rather densely hairy especially the last three. The first segment is short, the second very little longer, the third twice as long as the second, the fourth equal to the third, and the fifth a little longer. Each segment is gradually enlarged distally.

The *labium* (Fig. 19) is elongate with a large submental region divided into two distinct and free sclerites, the primary and secondary submental plates[1].

The *primary submental plate* (*sm*[1]) is slightly broader than long, widest nearer the base, the front and hind margin straight and the lateral margins convexly curved, the postero-lateral angles rounded off. It is rather strongly arched longitudinally and bears scattered, rather coarse, setæ, chiefly near the lateral margins.

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[1]These are the sclerites usually known as submentum and mentum respectively.

The *secondary submental plate* (*sm*[2]) is a little more than half as wide as the primary plate and nearly half as long as broad. It bears a few scattered setæ.

The conjunctiva between submentum and mentum is unusually well developed and is partly exposed, this exposed part bearing a small median sclerotized area.

The *mentum*[2] (*m*) is cleft half way to its base, the remaining part being divided by a deep median groove which marks the position of the labial apodeme. This is a strong internal ridge which curves from the base of the mentum forwards and upwards between the bases of the glossæ to the base of the hypopharynx, where it becomes continuous with the apex of the V-shaped sclerite of the latter. No sutures are present to mark off the palpigers from the more mesial region of the mentum.

The *paraglossæ* (*pg*) are separated from the mentum by a faint suture distinct only in dorsal or lateral view. They are not divided into two segments. They are slender, sub-cylindrical, slightly incurved, somewhat emarginate mesially towards the apices, which are bluntly rounded and densely covered with fine sensillæ. Their ventral surfaces and mesial margins are thinly clothed with ordinary setæ, of which one, near the apex, is longer than the others.

The *glossæ* (*gl*) are separated ventrally from the mentum by a fine suture. They lie in the same plane as the paraglossæ and are a little shorter than the latter. They are flat, elongate-triangular, with straight sides, slightly emarginate mesially before the apices, which are bluntly pointed and beset with fine sensillæ.

The *labial palpi* (*lp*) are about as long as the primary submental plate, the first two segments subequal in length, the third about a third longer than the second, each a little enlarged distally. The first segment has only a few coarse setæ, the second a few coarse ones mixed with shorter, finer hairs, the third thickly covered with the finer type of hairs, a few of which are larger than the others.

MUSCLES OF THE HEAD.

The Labrum (Figs. 26–29).

1. *Levators of the labrum.*—A pair of contiguous muscles forming a flat median bundle of parallel fibres arising from the middle of the frons just in front of the frontal sutures and inserted on the base of the dorsal wall of the labrum. (The *anterior retractors* of Snodgrass.) These muscles, judged by the movements of living insects, act both as levators and retractors.

2. *Depressors of the labrum.*—Two muscles arising from the frons a little anterior and lateral to the origin of the levators, the fibres running parallel and passing forwards and slightly outwards to be inserted on a small dorsal process of the tormæ at the base of the ventral wall of the labrum. (The *posterior retractors* of Snodgrass.) These muscles appear to act both as depressors and retractors of the labrum.

[2]This is the sclerite usually called prementum and also known as the stipulae and the labiostipites.

The Stomodaeum (Figs. 26–29).

3. *Dorsal dilators of the buccal cavity.*—A pair of flat muscles arising from the base of the dorsal wall of the labrum laterad of the insertion of its levator muscles and passing backward and inward to be inserted on the roof of the buccal cavity.

4. *Retractors of the mouth angles.*—A pair of stout bundles of somewhat converging muscle fibres arising from the frons close to the origin of the depressors of the labrum, passing downward, forward and slightly inward to be inserted on the upper part of the oral branch of the hypopharyngeal suspensorial bars.

5. *Protractors of the mouth angles.*—A pair of very slender muscles arising from the epistomal ridge just mesad of the antennal fossæ and passing downward, backward and inward to be inserted on the posterior margin of the oral branch of the hypopharyngeal suspensorial bar.

6. *First dorsal dilators of the pharynx.*—A pair of very slender muscles arising from the frons close to the base of the clypeus and about midway between its lateral margin and the median line, and passing downward, inward and backward to their insertion on the roof of the pharynx just laterad of the frontal ganglion.

7. *Second dorsal dilators of the pharynx.*—A pair of somewhat larger muscles arising from the frons close to the origin of the depressors of the labrum and just behind a line drawn through the hind margin of the antennal sockets, the fibres passing downward and slightly inward to their insertion on the roof of the pharynx near the middle line, on each side of the posterior part of the frontal ganglion.

8. *Third dorsal dilators of the pharynx.*—A pair of long slender muscles arising from the parietal areas near the middle line and about half way between bases of antennæ and occiput. They pass downward and forward, spreading out fanwise, and are inserted on the roof of the pharynx behind the bases of the anterior arms of the tentorium.

9. *Lateral dilators of the pharynx.*—A pair of short fan-shaped muscles with somewhat divergent fibres, which arise from the mediodorsal surface of the base of the dorsal arms of the tentorium and, passing inward and slightly downward, are inserted on the lateral wall of the pharynx.

10. *First ventral dilators of the pharynx.*—A group of short fibres arising from the anterior part of the dorsal surface of the body of the tentorium, continuous with the origin of the lateral dilators, and inserted on the ventral wall of the pharynx. With the lateral dilators they form a continuous band of fibres across the ventral half of the pharynx in this region.

11. *Second ventral dilators of the pharynx.*—A very slender group of fibres arising on each side from the posterior arms of the tentorium close to the occipital foramen and passing forward to their insertion in the ventral wall of the pharynx opposite the insertion of the third dorsal dilators of the pharynx.

The Antennæ (Figs. 22–26).

12. *Levator of the antenna.*—A fairly stout bundle of slightly convergent fibres, arising from the upper part of the dorsal arm of the

tentorium and passing forward and slightly outward, to be inserted by a short tendon on the medio-dorsal part of the base of the first antennal segment.

13. *Inner depressor of the antenna.*—A flat muscle arising by a very broad base from the ventro-lateral surface of the anterior and dorsal arms of the tentorium and the included angle. Passing forward and outward the fibres converge to their insertion on the ventro-lateral part of the base of the antennæ.

14. *Outer depressor of the antenna.*—A flat fan-shaped muscle arising from the ventro-lateral surface of the dorsal arm and adjacent part of the body of the tentorium, below the depressor, the fibres passing outward and forward to a tendon which is inserted in the postero-lateral part of the base of the antennæ.

15. *Extensor of the flagellum.*—A stout bundle within the scape, arising dorsally from its base just beyond the insertion of the levator muscle and inserted dorsally on the basal margin of the pedicel.

16. *Flexor of the flagellum.*—A somewhat smaller muscle arising ventrally from the base of the scape just beyond the pivot on which the antenna turns, and inserted ventrally on the basal margin of the pedicel.

The Mandibles (Figs. 26, 28, 31, 32).

17. *Abductor of the mandible.*—A slender muscle arising from the dorso-lateral region of the head capsule as far back as the occipital region, the fibres laterad of the tergal adductor (18), converging forward to their insertion into the lateral part of the base of the mandible, which is somewhat emarginate at this point. The greater part of the muscle lies directly behind the eye.

18. *Tergal adductor of the mandible.*—A large, powerful muscle, arising from the dorso-lateral, lateral and occipital regions of the head capsule, the fibres in two main heads, a larger one from the dorsal, lateral and postero-lateral regions, subdivided into two or three smaller groups, and a smaller head arising from the postero-dorsal region. Both bundles consist of numerous converging fibres, which are inserted on a strong tendon attached to the inner angle of the base of the mandible. The tendon is stout and subcylindrical at base but spreads out behind into a broad, thin lamina, to which the muscle fibres are attached.

19. *Tentorial adductor of the mandible.*—A very short, fairly thick muscle arising from the dorsal surface of the anterior arm of the tentorium and passing forward and upward to be inserted on the dorsal wall of the mandible within its cavity and near the base.

20. *Hypopharyngeal adductor of the mandible*[3].—A very small muscle arising within the cavity of the mandible from the dorso-lateral surface, at about the proximal third, the fibres passing backward and inward to an extremely fine tendon which is inserted on the mandibular branch of the suspensorial bar of the hypopharynx.[4]

[3]This muscle, as shown by Snodgrass ('28) is morphologically a vestigial ventral adductor of the mandible, but, if it functions at all, it probably moves the hypopharynx rather than the mandible (v. Mangan '08).

[4]The exact point of insertion of this muscle has not been observed.

The Maxillæ (Figs. 33–34).

21. *Abductor of the maxilla.*—A somewhat conical muscle, broadest at its origin on the postero-ventro-lateral region of the head capsule, including parts of the parietal and occipital areas. The fibres converge as they pass forward to their insertion on the end of the basal arm of the cardo.

This muscle, in *Dissosteira*, is regarded as a promotor by Snodgrass ('28), but in *Grylloblatta* it seems to have the function of an abductor, and as such it has been considered by most authors.

22. *Adductor of the maxilla.*—A broad, flat muscle arising from the lateral margin of the body of the tentorium along its entire length, the fibres converging as they pass outward to their insertion on the cardo. Most of the fibres are inserted laterad of the ridge and close to the articulation with the stipes, but a small group is inserted mesad of the ridge. In the specimen figured a few fibres were inserted on the stipital side of the articulation.

23. *Flexor of the stipes.*—A broad, thick muscle, lying beneath the adductor of the maxilla, arising from the whole length of the body of the tentorium near its lateral margin and from the anterior surface of the posterior arm of the tentorium, the fibres converging slightly as they pass outward and slightly forward to their insertion on the mesial area of the stipes and the stipital ridge.

24. *Cranial flexor of the lacinia.*—A long, slender muscle with parallel fibres arising from the occipital region of the head capsule, passing forward and downward beneath the adductor of the mandible and above the tentorial muscles of the maxilla to its insertion on the inner side of the base of the lacinia.

25, 26. *Stipital flexors of the lacinia.*—There are two of these, a stout dorsal muscle and a much smaller ventral one. The dorsal muscle (25) arises from the outer wall of the stipes, passes obliquely across the stipes, with slightly converging fibres, to its insertion on the base of the lacinia immediately laterad and distad of the insertion of the cranial flexor. The ventral muscle (26) arises from the basal half of the ventro-lateral wall of the stipes, passing forwards and slightly inwards to its insertion on the outer part of the base of the lacinia, ventral to the insertion of the dorsal muscle. These two muscles are represented in *Blatta* and *Dissosteira* by a single digastric muscle.

27. *Flexor of the galea.*—A flat bundle arising by two or three heads from the outer wall of the stipes between the two stipital flexors and passing forward beneath the palpal muscles to its insertion on the inner side of the base of the galea.

28. *Extensor of the maxillary palpus.*—A slender bundle arising from the ventral wall of the stipes distal to the origin of the ventral stipital flexor and passing outward and forward to its insertion on the posterior edge of the base of the first palpal segment.

29. *Flexor of the maxillary palpus.*—A bundle of similar size to the preceding, arising from the ventral wall of the stipes, just distad of the origin of the extensor of the palpus, and following a similar course to the latter to its insertion on the anterior edge of the base of the first palpal segment.

30, 31, 32, 33. *Muscles of the maxillary palpus.*[5]—A single muscle for each segment, viz., an extensor of the second segment and a levator of the third segment, both arising in the basal part of the first; a flexor of the fourth segment arising from the posterior wall of the third; and a flexor of the fifth segment arising from the anterior wall of the fourth.

Labium and Hypopharynx[6] (Figs. 30, 35).

34. *Lateral retractors of the labium.*—A pair of stout bundles of parallel fibres, becoming distally compressed, each arising from a tubercle on the ventral margin of the posterior arm of the tentorium and passing forward to a broad insertion on the lateral basal margin of the palpiger (sides of mentum).

35. *Median retractors of the labium.*—A pair of contiguous muscles with parallel fibres, arising from the middle region of the primary submental plate and passing forward to a broad insertion on the basal margin of the mentum.

The distal retractors of the labium, usually found in orthopteroid insects, are wholly absent in *Grylloblatta*.

36. *Dorsal dilators of the salivary orifice.*—A pair of short muscles arising from the suspensorial bars of the hypopharynx and converging downward to a common insertion on the base of the ventral wall of the hypopharynx; immediately above the aperture of the salivary duct (*sd*).

37. *Ventral dilators of the salivary orifice.*—A similar pair of muscles arising from the sides of the palpiger, immediately distal to the insertion of the lateral retractors of the labium, and converging upward to their insertion on the median labial apodeme immediately below the aperture of the salivary duct.

These two pairs of muscles apparently act not only as dilators of the aperture of the salivary duct but also as compressors of the salivary reservoir by approximating the upper wall of the hypopharynx and the lower wall of the labium.

38. *Protractors of the hypopharynx.*—A pair of small bundles each arising from the ventral wall of the mentum, near the base of the palpus, and converging upward to their insertion on the fold between the hypopharynx and labium, on each side of the aperture of the salivary duct.

According to Snodgrass this muscle, in *Dissosteira*, is inserted on the sides of the salivary cup, but in *Grylloblatta* there is no such cup, the salivary duct opening by a simple orifice from which the insertions of the muscles are quite distinct.

The *retractors of the hypopharynx*, generally present in orthopteroid insects and the largest muscles attached to the hypopharynx, are wholly absent in *Grylloblatta*.

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[5]These muscles are named here in accordance with the movements of the segments in relation to the longitudinal axis of the appendage, rather than to that of the insect as a whole, as Snodgrass has done in the case of *Dissosteira*. Unless this method is followed there seems to be no possibility of achieving uniformity in the terminology of homologous muscles in different insects, since the position of the head and consequently of the mouth-parts varies greatly in relation to the longitudinal axis of the body.

[6]See also No. 20.

39. *Flexor of the paraglossa.*—A flat bundle arising from the outer half of the base of the labiostipes and inserted into the inner part of the base of the paraglossa.

40. *Flexor of the glossa.*—A somewhat smaller bundle arising from the inner half of the base of the labiostipes and inserted into the inner part of the base of the glossa.

41. *Abductor of the labial palpus.*—A very small bundle of short fibres, arising from the lateral wall of the palpiger and inserted on the ventro-lateral part of the basal margin of the first palpal segment.

42. *Adductor of the labial palpus.*—A much larger muscle than the last, arising from the distal end of the labial apodeme between the bases of the glossæ and passing outward to its insertion on the anterior side of the basal margin of the first palpal segment.

43, 44. *Muscles of the palpal segments.*—Two muscles, an extensor of the second segment (43), arising from the posterior side of the base of the first segment and inserted on the posterior side of the base of the second segment, and a flexor of the third segment (44) arising on the anterior side of the base of the first segment and inserted on the anterior side of the base of the third segment.

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ABBREVIATIONS.

ab—Tendon of mandibular abductor.
ad—Tendon of mandibular adductor.
af—Antennifer.
an—Antenna.
ap—Anterior tentorial pits.
as—Antennal socket.
at—Anterior arm of tentorium.
cd—Cardo.
cda—Basal arm of cardo.
cdr—Cardinal suture or ridge.
c—Cerebral ganglion.
cl—Clypeus.
cv—Occipital condyle.
dm—Dorsal mandibular articulation.
dm'—Dorsal articular surface of mandible.
dt—Dorsal arm of tentorium.
ec—Epicranial suture.
es—Epistomal suture.
fg—Frontal ganglion.
g—Galea.
gl—Glossa.
hs—suspensorial apparatus of hypopharynx.
hsm—Mandibular branch of same.
hso—Oral branch of same.
hv—Ventral V-shaped sclerite of hypopharynx.
hy—Hypopharynx.
l—lacinia.
li—Labium.
lp—Labial palpus.
lr—Labrum.
lt—Tubercle for attachment of median retractor muscle of labium.
m—Mentum.
mc—Mandibular condyle.
md—Mandible.
mx—Maxilla.
mxc—Maxillary condyle.
mxp—Maxillary palpus.
o—Mouth opening.
oc—Occipital suture.
oe—Oesophagus.
pg—Paraglossa.
poc—Postoccipital suture.
pp—Posterior tentorial pits.
ps—Parietal suture.
pt—Posterior arms of tentorium.
sd—Opening of salivary duct.
sg—Subgenal suture.
sgl—Subgalea.
sm^1—Primary submental plate.
sm^2—Secondary submental plate.
sog—Suboesophageal ganglion.
st—Stipes.
str—Stipital suture or ridge.
t—Body of tentorium.
tm—Torma.
vm—Ventral articulation of mandible.

EXPLANATION OF PLATES.

(All Figures are from preparations of *Grylloblatta campodeiformis* Walk.)

Plate I.

Fig. 1. Head capsule, dorsal view.
Fig. 2. Same, ventral view.
Fig. 3. Same, left lateral view.
Fig. 4. Area including left eye and antennal socket, dorso-lateral view.
Fig. 5. Area including right eye and antennal socket, from below and within.
Fig. 6. Hypopharynx, dorsal view.
Fig. 7. Hypopharynx, ventral view, with labium attached.
Fig. 8. Anterior view of mouth-opening and surrounding parts, showing relations of the suspensorial apparatus of the hypopharynx to the mouth opening and mandibles.
Fig. 9. Left mandible, dorsal view.
Fig. 10. Right mandible, dorsal view.
Fig. 11. Right mandible, ventral view.
Fig. 12. Left mandible, ventral view.
Fig. 13. Right mandible, mesial view.
Fig. 14. Left mandible, mesial view.
Fig. 15. Right mandible, base from below.
Fig. 16. Head from beneath, with labium and left maxilla removed. Except the oesophagus, main tracheae, and muscles from tentorium to right maxilla, only the skeletal parts are shown.

Plate II.

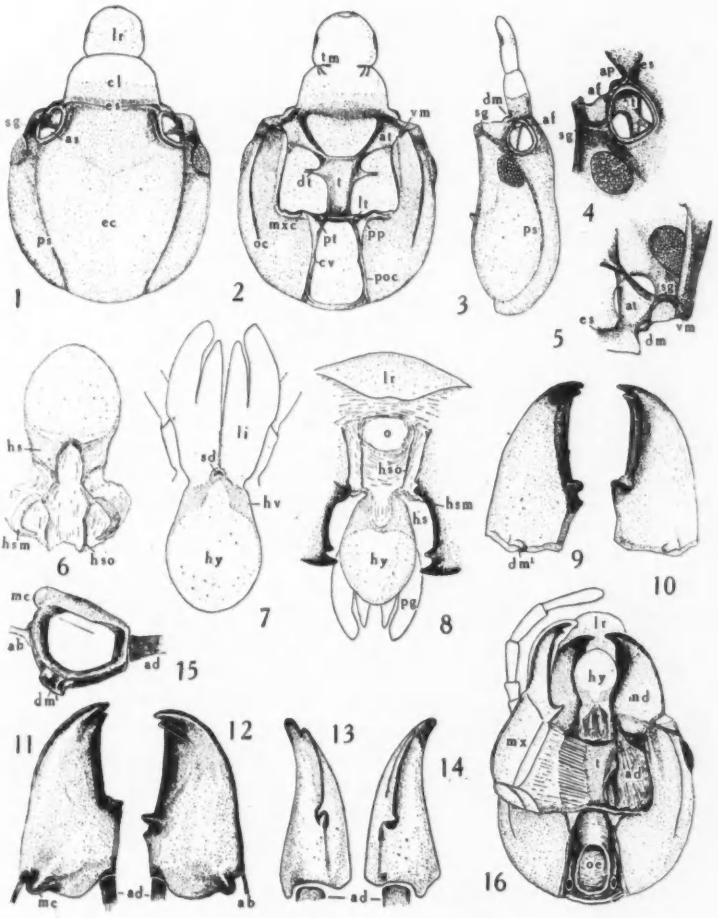
Fig. 17. Left maxilla, ventral view.
Fig. 18. Same, dorsal view of potash preparation.
Fig. 19. Labium, ventral view.
Fig. 20. Proximal segments of antenna.
Fig. 21. Distal segments of antenna.
Fig. 22. Basal muscles of antenna, right side, dorsal view.
Fig. 23. Same, left side, dorso-lateral view.
Fig. 24. Same, left side, ventral view.
Fig. 25. Base of antenna, semi-diagrammatic, showing insertions of muscles.

Plate III.

Fig. 26. Dissection of head, right side, dorsal view, muscles in situ.
Fig. 27. Dorsal view of pharynx, showing insertions of muscles.
Fig. 28. Dissection of head, left side, showing positions of stomodaeal and hypopharyngeal muscles.
Fig. 29. Left view of pharynx with labrum, hypopharynx and labium, attached, showing connections of these parts and associated muscles.
Fig. 30. Muscles of labium and hypopharynx from within (postero-dorsal view of labium, postero-ventral view of hypopharynx).

Plate IV.

Fig. 31. Left mandible with part of dorsal wall removed, showing muscles.
Fig. 32. Same, with part of ventral wall removed, showing hypopharyngeal adductor within.
Fig. 33. Right maxilla, dorsal dissection of muscles.
Fig. 34. Same, with cardo extended and muscle 25 cut and turned over to show underlying muscles (26, 27, 29).
Fig. 35. Labium, dorsal dissection of muscles.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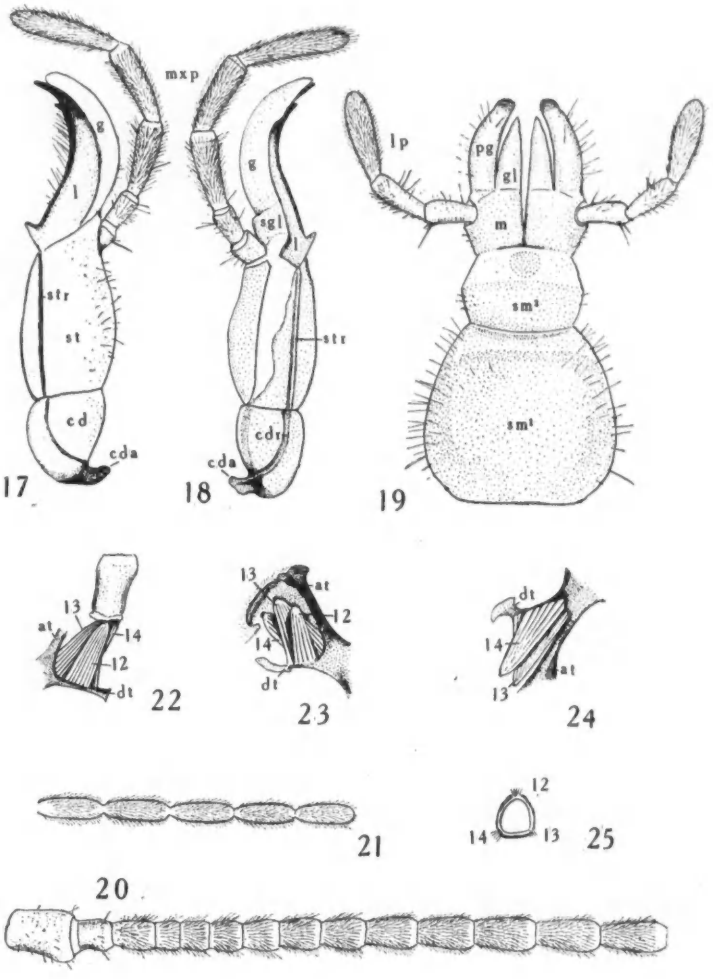
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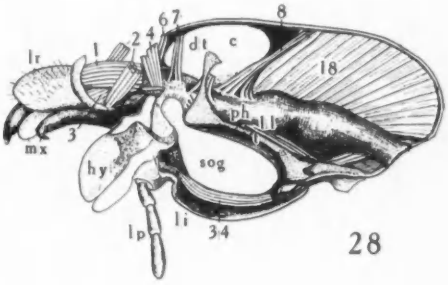
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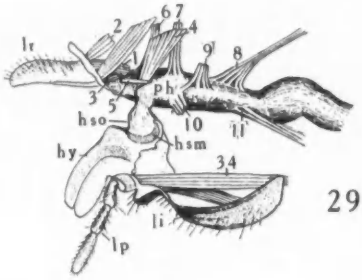
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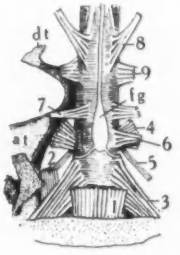
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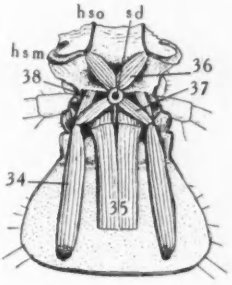
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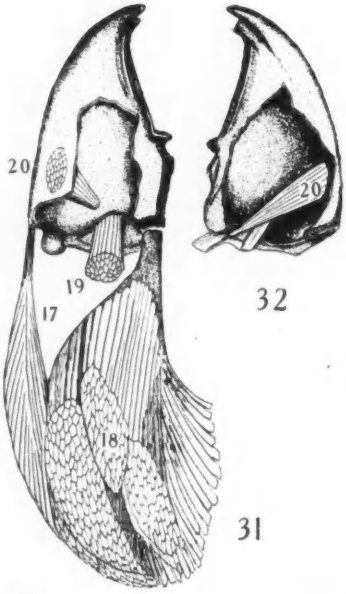
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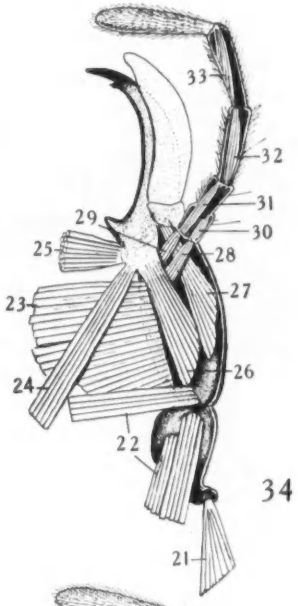
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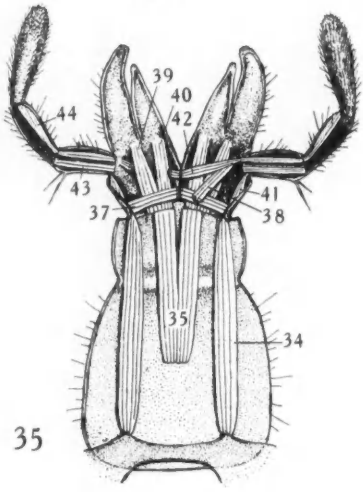
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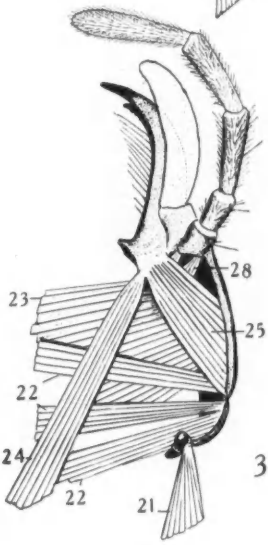
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SYMPHYLA FROM NORTH AMERICA.

WILLIAM A. HILTON,
Department of Zoology, Pomona College.

For the past few years I have collected specimens of this group where it was possible. To the northward I have searched in Canada and into Alaska and as yet not a single specimen from the more northern regions has come to me. Also in the northwestern United States I have as yet very few. Some specimens were collected in the eastern states, in California, in Lower California, in and near Mexico City and in Cuba. Many other places were searched without specimens. I have looked for them in many western National parks without success. This does not mean that they do not occur in these places, it merely means in some cases at least that the most favorable conditions of moisture and vegetation were not encountered in many of the places where a careful search was made.

Two works particularly have given me a basis for determination and classification, the extensive and comparatively recent paper of Hansen (1), 1904, and the brief but valuable paper of Bagnall (2), 1913. The many other papers referred to in the study were less useful and need not be discussed at this time.

Under the Subfamily Scutigerellinæ as defined by Hansen and Bagnall I have studied the following species:

Subfamily **Scutigerellinæ**

Scutigerella immaculata Newport. These were collected from a number of places in California, from Cuba, from New York State, and from Mexico.

Pseudoscutigerella americana n. sp. This type of a new genus may later be shown to belong to a distinct subfamily. I have representatives all of which seem to be the same species, from New York State, and from several situations in California. The type material was from Evey canyon near Claremont, California.

Hansinella californica n. sp. Specimens were collected in Southern California about fifty miles southwest of Claremont at Glen Ivy.

Subfamily **Scolopendrellinæ** Bagnall.

Scolopendrellopsis sensiferis n. sp. These were collected from Live Oak Canyon near Claremont.

Scolopendrellina californica n. sp. The new species and the type for the genus came from South Hills near Pomona, California.

Symphylella isabellæ Grassi. Specimens agreeing quite closely with this European species were found in a number of places in Southern California, near Redlands, near Claremont, near San Dimas. Some were found at Laguna Beach, some at Catalina Island, and Santa Cruz Island. They were also found in several places in Lower California.

Symphylella vulgaris Hansen. Specimens which seem to be this species were found near Claremont, near Pomona, near Corona and several other places in Southern California.

Symphylella santa n. sp. These were found on Santa Cruz Island.

Symphylella brevipes Hansen. These were collected in the higher mountains of Southern California, a number of other places in Southern California, near Mexico City and in Cuba.

Symphylella cubæ n. sp. These were collected near Artesia, Cuba.

Scutigerella immaculata Newport.

I have collected specimens of this widely distributed species in a number of places. As there are some variations some indication of these will be given in the list.

Laguna Beach. A hundred or more specimens were collected near cultivated plants.

The longest were 5.8 mm., the head was about .4 mm. long and a little less wide.

The joints of the antennæ were variable but usually about 25 in number.

The first segment was .19 mm. long and .304 mm. wide. The second segment was .247 mm. long by .399 mm. wide.

The cerci were .342 mm. long by .038 mm. wide with the terminal spine .038 mm. long.

The basal appendages of the legs were in some cases more lobe-like than elongate, but this did not seem to be true for all. The first pair of legs in the first specimen mentioned were .319 mm. in length and the second pair were .418 mm. long. The last pair of legs was .446 mm. long.

In other features this and other specimens collected at the same place do not differ materially from other described members of this species.

Specimens from a small canyon near Lake Elsinore. Length, .5 mm. Head length, .266 mm. The ocellus is .023 by .021 mm. The first pair of legs is .152 mm. in length. The other legs are about .456 mm. in length. There are 17 joints in the antenna.

Specimens from Glen Ivy near Lake Elsinore, California. Total length, .95 mm. Length of the first leg, .076 mm. Length of the second leg, .104 mm. The last leg is .123 mm. The cerci are .204 mm. Sense papillæ are evident at the tip of the antenna and the head triangle has three short hairs. There are no other distinctive features.

Waverly, New York. From the "Glen." The total length is 2.5 mm. There are eighteen joints in the antennæ. There seem to be few hairs on the dorsum, the eye spot is wider than long. This specimen is like others except that some are immature.

Mexico Valley. Specimens from two places do not differ from usual descriptions of this species. Specimens were obtained from situations about twenty miles distant from each other, some were among cultivated plants and others in wild land.

In some the head rod was shorter and with lateral branches not present.

Cuba. About twenty miles south of Havana in wild land. One of the specimens was of the following measurements: Total length, 2 mm. The head was .16 mm. long by .137 mm. wide. The first leg is .133 mm. long, the other legs .247 mm. long. The head rod is straight with slight lateral branches. There are two hairs in the head triangle.

Pseudoscutigerella n. genus.

No scutæ marked, the whole body intricately folded and lobed with few short hairs. The segments are broadly rounded at their outer edges but form almost a straight line from side to side.

The head is slightly broader than long. The central bar not heavy with delicate lateral branches at right angles well forward and delicate branches at the caudal end. The head has few small hairs except a fringe at the cephalic margin. The head is not much wider than the general neck region. The head and body finely granular.

The legs have a fine pubescence but few long hairs. Internal supporting rods are evident connecting each pair. The first pair of legs well developed. The two terminal claws are prominent and equal.

The cerci are without stripes on the terminal area. The terminal hair is evident. The sense calicles near the base of the cerci are of the usual type.

The exopods are almost if not entirely lacking. Some low mounds in certain places suggest them.

Pseudoscutigerella americana n. sp.

(Fig. 1, a, b.)

Length, 1.5 mm.

Head.—Length, .085 mm.; breadth, .1105 mm. The head rod is delicate, slender with a delicate cross line well forward and three small branches at its caudal extremity. The hairs on the dorsal surface are few and small, about eight in the type, but the front margin of the head has ten rather stronger ones at the front margin and others deeper. The ocelli are about .0148 mm. in diameter.

The Antennæ—17 joints, few hairs.

Body.—The divisions are well marked but with no indication of special plates. A few dorsal hairs are found on each segment. There are about 26 transverse foldings of the body or several for some segments, sometimes as many as three. On each side dorsally the hairs are about as follows: the first segment, 3; the second 4, with one medial; the third segment, 5; the fourth, 4. The next to the last segment has two on each side and two medial. The last segment has three lateral and two medial.

Legs.—The first leg is .09525 mm. long, with the joints of the following lengths beginning with the longest 5–(4,3,2)–1. The hairs on the first leg are: 3 on last joint, 1 on next to last, 2 on 3, 1 on 2. The second leg is .11475 mm. long and the joints are as follows: 5–3–4–2–1. Near the base of this is a rosette of ridges about an opening and near is a low fleshy lobe with no hairs. An internal rod runs between the pair of legs. There are four prominent hairs on the ventral side of the last joint. The third leg is similar to the last but three prominent hairs are near the tip of the fifth joint. The spiracular opening is surrounded by a rosette of ridges. The thick more or less median pair of low mounds like in the last has four short hairs. The 4th leg is similar but with no spines on the median pair of elevations between the legs.

The spiracular opening if it is such near the seventh pair of legs is elliptical with ridges running from it and surrounded by two rows of dots on each side. Opposite the 12th leg the spiracular opening is about one half as broad as the others with a whorl of ridges about. There are pairs of openings such as described opposite and between each pair of legs except the 9th, 10th, and 11th. The 12th leg is .119 mm. long. The joints are as follows beginning with the longest: 5–2–3–4–1. The hairs on the joints are as follows: 5, 3 hairs; 4, 2; 3, 1; 2, 2.

Cerci.—Length, .1147 mm., of which the terminal hair is about half in each case. The cirrus is about one-third the total length. There are nearly five rather regular whorls of short stiff hairs on the base

with indications between them of about four cross lines suggesting scales. The sense calicles near bear the usual long hair and have one other short hair near the rim of the large one. Near the calicle, between it and the cercus on each side is a spine with a basal joint as long as it is, the spine and its base being just a little shorter than the cercus.

The type and several specimens were collected in Evey Canyon near Claremont, California, November, 1929. Another bottle of specimens from Laguna Beach seems to be the same species. Other specimens from Ellis Creek, Waverly, N. Y., and the Glen, Waverly, N. Y., seem to be the same species. Minor variations in dorsal setæ and in some of the proportions are not enough to separate them from each other or from the California specimens from 2 localities.

Hanseniella californica n. sp.

(Figs. 2a, 2b, 2c, 2d, 2e.)

Length, 2.5 mm.

Head.—Length, .19 mm. by .26 mm. wide. The head rod is rather thick, its center branching into a wide angle forward and dividing into a narrow angle caudally. There is no head triangle. The head has quite a number of hairs dorsally, on each side two or three cephalic lateral hairs are twice the length of most of the others. Between the antennæ are two long hairs.

Antennæ.—17 joints in the type. The basal joints have rather irregularly disposed long hairs, the hairs being considerably longer than the joints. The tip joints have rather longer hairs than usually found here with a tendency for two imperfect whorls. The hairs here are not as long as the joints. There was little indication of other special sense organs on the antennæ in addition to the rather stiff hairs.

Scuta.—The first scutum is .238 mm. wide by .0935 mm. long. There is forward pointing seta on the cephalic lateral region on each side. This hair is .0425 mm. long. On each side pointing backwards are two hairs longer than the rest or about .034 mm. long, while the other prominent hairs are at the longest about ¾ of this length. The second scutum is .30 mm. wide and .112 mm. long. On the lateral margin on each side is a large hair directed somewhat forwards. These are .036 mm. long. In addition there are two long hairs directed caudally. The third and all the remaining scuta but the last have two or three especially long hairs directed backwards and a considerable number directed forward. On the last and the lower segments although there are many stout hairs the differences between them are not so marked as towards the head.

Legs.—The first legs are .28 mm. long and .0425 mm. wide at the widest. In length the joints are as follows beginning with the longest: 5–2–3–1–4. The claws are equal, the tarsus has two long dorsal hairs. The tibia has a group of four strong hairs at its tip and on the dorsal side. The first joint has at least one long hair and the second joint of the leg four strong ventral hairs. There is a strong hair on the dorsal side of the third leg joint.

The last as well as the other legs are somewhat similar. In the last leg is .34 mm. long and .068 mm. wide at its widest. The first joint has one strong hair, the second one on its ventral side, the third joint two dorsal hairs, the third joint has five strong dorsal hairs, the last joint has two strong dorsal hairs. The joints of the last leg are as follows beginning with the longest: 5–4–2–3–1. The claws on the first and last legs are even in length but some of the more centrally placed legs have uneven claws. In addition to the numerous long hairs on all legs all joints have many very fine hairs covering them.

Basal appendages of the legs were noted; they were about .0425 mm. long by .0085 mm. wide with the spine .01275 mm. long as part of the total length.

Cerci.—These were .206 mm. long by about .05 mm. broad at their base. They are conical and clothed in about four imperfect whorls of long hairs. The terminal hair is about half as long as the cirrus.

Terminal Sense Hair.—The mound bearing this long hair is well marked, at the base are nine or more stiff spines in two nearly equal groups.

Locality.—Specimens were collected in Glen Ivy with at least two other species. The type is in the Pomona College collection. Another specimen from Evey Canyon some 50 miles distant seemed to be the same.

Distinctive Characters.—The distribution of the setae on the scuta, the spines on the legs are the distinctive features.

Scolopendrellopsis Bagnall.

Scolopendrella, Gervais.

The first pair of legs is well developed but not more than one half as long as the second pair. The cerci have several transverse lines across their distal parts. The central rod of the head is without lateral branches. The scuta are sharp pointed but without any striped belt.

Scolopendrellopsis sensiferis n. sp.

(Figs. 3a, b, c.)

Length, 1.67 mm.

Head.—Length, .133 mm.; width, .114 mm. The head rod is without lateral branches except at the extreme caudal end where there are two short lateral and one central portion. The rod seems divided or jointed about at its middle. The triangular area back of the head is almost lacking. The hairs on the dorsal part of the head are short and not numerous. There are four quite prominent ones between the antennæ. In addition to this there are eight short hairs on the central dorsal surface on each side and six more caudo-lateral also on each side. The mandibles have a number of prominent teeth.

Antennæ.—In the type there are 17 joints. The two basal joints have almost no hairs and beyond this there is a single whorl of rather

short hairs. In every case these are much shorter than the segments to which they are attached. The last joint has a few short sense knobs and about six short hairs near its top. The next five joints in addition to short but not numerous hairs each have one or more prominent circular pits. In the type the next to the last terminal joint has the most, the next two joints back about the same and the next two progressively less.

Scuta.—The width of the first body segment is .114 mm., its length is .027. The total width of the second segment is .119 mm., its total length is .0425. The length of the points is .0425. The distance between the points is .0765. The third segment is .0765 mm. long and .136 mm. wide with the scuta .0765 mm. wide. Between the points the distance is .0425 mm. The length of the spines is .051 mm. The next to the last dorsal division is .034 mm. long and .136 mm. wide. The dorsal plate is .101 mm. wide. The points are .0425 long and .0574 mm. between them.

The last division from above is .1275 mm. long.

The first segment above has three hairs on a side, the outer being twice the length of the inner four. The second segment has six hairs in the more cephalic row, four in a central row, three on each spine and one in between. The third segment and some others are similar to this last. The next to the last segment has two rows of five hairs, then three on each spine and two between them. The last dorsal division has beginning with the cephalic region rows of hairs as follows: 4–6–3–3–2–3–4.

Legs.—The first leg is .05 mm. long. The joints beginning with the longest are: 3–5–4–1–2. The basal leg rods are separate and point cephalad. The second legs are .1 mm. long with the joint lengths as follows: 5.4.2.3.1. The leg rods are arched and connected from side to side in this and many other legs. The last leg is .0935 mm. long; its joints are 2–5–3–4–1. The leg rods are at an angle and not united. All the legs bear two like claws. There are but few dorsal hairs on any of the legs. The first leg has two hairs on the last joint and the second leg has one dorsal on the last joint, one on the next to the last and two hairs on the next joint. The last leg has one dorsal hair on the second, third and fourth joints and two on the fifth.

Basal appendages on the legs were very small. They were seen on the 7 last legs but may be on the others; they were .00425 mm. long by .00215 mm. wide.

Cerci.—These were .103 mm. long and one third as wide. There were fewer sense hairs on the base at its inner side. In all there were about 7 whorls of hairs of moderate length with eight transverse striations at the end of the appendage.

Terminal Sense Hair.—This is on a moderate elevation with three short hairs near its origin.

Locality.—Specimens were obtained in Live Oak Canyon, near Claremont, Calif., in May, 1929. The type in Pomona College collection is not quite mature, but seemed the best for

study and description. The sex openings and tracheal openings were not prominent.

Distinguishing Characters.—The peculiar sense spots on the antennae, the head rod, and the character of the mandibles are the most distinctive features. The strong chitinous rods connecting the legs except the first and the last are also marked, as are the rods of the first and the last from all the others.

Scolopendrellina new genus.

The first body segment bears a well-developed leg only slightly shorter than the others. All claws even. The points of the dorsal plates sharp pointed but short. The first six segments of the body shortened and somewhat telescoped. The plates overlap much more than is usual. The head is slightly longer than wide, the antennæ are with rather long hairs on both basal and tip segments. The head rod is heavy and unbranched except towards its base where it forks and at its forward end where it has branches almost at right angles. Each of these lateral branches meets a short longitudinal rod at the base of each antenna. The cerci are just slightly longer than the first leg and about twice as long as wide with about five whorls of moderately long hairs. The terminal hair lobe has a long hair and two shorter ones near. There is another lobe off from this which bears two small hairs. The jaws are not toothed and no basal appendages were seen on any leg.

Scolopendrellina californica n. sp.

(Figs. 4a, b, c, d.)

Length, 2.5 mm.

Head.—Length, .204 mm.; width, .153 mm. The head rod is strong, unjointed and branched only at its extremities. Posteriorly it is branched at a sharp angle but forward it branches almost at a right angle. Each branch forward is branched again almost at a right angle. The jaws are long and without separate teeth. The head bears quite a number of moderately short hairs, about 64 in all. The ocelli are nearly circular, .0148 broad by .107 long.

Antenna.—There are 17 joints in the type. The two basal segments have each a single whorl of hairs about as long as the segment and from that point on other segments for a distance have nearly two whorls of hairs. In the last two segments the hairs are shorter and more scattered. The terminal joint has a short sensory knob.

Scuta.—The first six segments are shorter than the others and somewhat telescoped. The body is fairly broad and the scuta also. The points are sharp but rather short. The first segment is .136 mm. wide and .107 mm. long; the second segment is .034 mm. long and .136 mm. wide. Between the spines the distance is .068 and the spines are .02975 mm. long. The third scutum is .085 mm. long, .17 mm.

wide with a distance between them of .0765 mm. Dorsally the first segment is short and without hairs. In the second segment there is a cephalic row of eight short hairs, two hairs on each spine and two short hairs between the spines. The third segment has a row of six, a row of four, three hairs between the spines and three on each spine. The following segments are somewhat similar. The last segment with spines has eight hairs in the cephalic and more central parts, two hairs on the spine and two hairs between the spines. The last segment has two lateral hairs and four caudal hairs.

Legs.—The first leg is .093 mm. long and .0297 mm. wide at the base. The leg segments are as follows beginning with the longest: 5–4–2–3–1. The second leg is .119 mm. long and .03 mm. wide, the joints are 5–4–2–3–1. The last leg is .154 mm. long and .0255 mm. wide. All claws are of equal size on each leg and usually rather blunt. No basal appendages were seen on the legs. The hairs were as follows. The first leg has a number of hairs near the claws and two prominent hairs on the third segment. In addition the second leg has a hair on the fourth joint and on the second joint. The last leg has a prominent ventral hair on the second segment a dorsal on the third, three on the fourth and four more or less on the dorsal surface of the last.

Cerci.—These are .101 mm. long and .0425 mm. wide, there are about five whorls of moderately developed hairs. There are about six cross striations on the tip of each of the appendages. The inner margin at its base does not bear hairs.

Terminal Sense Hair.—This is borne on a prominent lobe and has two shorter hairs at the base of the long one. A thick lobe or knob below the base of the hair bears two delicate hairs.

Locality.—Specimens were taken from South Hills near the city of Pomona. The type is in the Pomona College collection.

Important Distinguishing Features.—As this is the first species described for the genus, many of the characters given may not prove to be specific differences. The head rod is distinctive, the length of the first pair of legs, the rather blunt claws of the legs, the rather hairy head, the overlapping of the first six segments of the body, the rather short but sharp points on the scuta are also remarkable.

Symphylella Silvestri.

Scolopendrella, Gervais.

The first pair of legs lacking or represented by a wart-like knob without claws. All setæ naked and slender. The last pair of legs with three long dorsal setæ on the metatarsus and at least three similar ones on the tarsus. Cerci large and well clothed with hairs.

Symphylella isabellæ Grassi.

Many specimens from many distant parts of North America seemed to belong here as nearly as any place. Some of them differ from early descriptions of this species as well as from each other in minor points but after considerable study I have decided to place them here with some comments upon points of difference. In spite of many minor points which may later prove to be distinctive I am not as yet willing to describe any of these as distinct species.

Claremont, California, College Park. The head has about forty small hairs above. The head triangle has two hairs. The head rod is straight. The first segment has a row of six hairs. The second plate has a pair of cephalic backward pointing hairs. There are about 22 dorsal hairs on the first segment. There are 16 antennal joints. Total length, 2.5 mm.

Evey Canyon, near Claremont, California. The head is quite like the last, the second dorsal segment has a row of eight hairs. The second dorsal segment has no backward pointing hair but otherwise is similar to the last specimen but the points of the scutæ are not so sharp. Antennal joints 16 to 18 in specimens. Total length about 3 mm.

Redlands, California, (Several miles north). In these the terminal spines of the cirrus are rather long but no other marked feature was noted. Antennal joints 16, joints rather globular and flattened. Length, 3 mm.

Pudding Stone Canyon, near San Dimas, California. The most marked difference noted was in the fact that the first segment has but two hairs dorsally. The first segment has four rather large hairs before the spine, two more medial hairs, about four hairs on the spine and four hairs between the spines. The cirrus has a rather short curved terminal hair. Eighteen antennal joints and a body-length of 2.5 mm.

Laguna Beach, Orange Co., California, (North about a mile in a canyon). Like the others the head has numerous hairs. The head triangle has two hairs, the first dorsal plate bears six hairs. Prominent rods connect many of the legs. The basal segment of many of the legs have rather broad appendages. The two claws of the first pair of legs each bear three small teeth at their bases. The ocelli are about twice as long as wide. The cirrus bears a rather long terminal hair. Antennæ 16 to 18 joints. Total body-length, 2.5 mm.

Catalina Island, two miles west of Avalon. The head has fewer hairs than in some others, the eye spots are circular in outline. There is a moderately long terminal spine on the cirri. The first segment above bears four hairs. The second segment bears about 15 hairs above. Hairs are not so numerous on these specimens. The antennæ have 16 joints and a single whorl or rather short hairs. The total length is 3 mm.

Catalina Island, California, 20 miles north of Avalon. These are more hairy again. The head bears as many as 50 hairs above. The first body segment above bears 8 hairs. In some of the specimens the eye spots are circular, in others they are wider than long. The head rod has a number of branches at its cephalic end. There are two hairs in the little triangle back of the head in one specimen at least and in one at least there are but six hairs on the first body segment dorsally. The antennæ have 16 to 20 joints and the body length is 1.4 mm. in the specimen most studied but others are larger.

Live Oak Canyon, near Claremont, California. The head bears about 60 hairs, the head triangle two, the first segment dorsally eight hairs, the second segment dorsally about 24. One cephalic lateral hair points almost at right angle to the body. The eye is nearly circular in outline. Some of the leg claws seem slightly shorter than others. The terminal spine of the cirrus is quite marked. There are 20 joints on the antennæ and the total length of the body is 2.5 mm.

Bakersfield, California, (about fifty miles west in the hills). The dorsal hairs of the head are about 50. The head triangle has two hairs. The first body segment above has 8 hairs, the second about 25. The terminal hair of the cirrus is long. At the base of the terminal sensory hair are four very small spines. The antennæ are with 21 joints. The body length is 3.5 mm.

Santa Cruz Island at Pelican Bay, California. Hairs on the head triangle 2. The first segment dorsally has 6 setæ The second scutum has four hairs in a cephalic row, four hairs between the spines and three hairs on each spine. The spine of the cirrus is long. The antennæ have 16 joints. The body length is about 2.5 mm.

Santa Cruz Island, Lady Harbor, California. The head has less than 40 hairs dorsally. The head triangle has two haris. The first scutum has 4 hairs. The second has at least

20 hairs. In the specimen described the antennæ were broken. The total length was 1.2 mm.

Lower California, Mexico, about 50 miles from Tia Juana. The head had about 40 dorsal hairs. The head triangle two. The first scutum has a row of eight hairs. The second scutum has about 25 hairs. The ocellus is circular. The cercus has a short curved hair and in addition to the transverse striations there are minute dentitions on the side of the appendage near the base of the terminal hair. Antenna 14 joints but in this specimen they are apparently broken. The body length is 3.25 mm.

Lower California, Mexico, below Ensenada on the bay. The head has fewer hairs, about 30 above and two in the head triangle. The ocellus is one-fourth longer than wide. There are 18 joints in the antenna. The total length is from 2 to 3.5 mm. in the specimens collected.

Lower California, near San Tomas, Mexico. The head has quite a number of hairs, about 40 in all. The head triangle is without hairs in the specimen examined. There are from 17 to 19 joints in the antennæ and specimens were from 3 to 3.5 mm. long.

Symphylella vulgaris Hansen.

Specimens which seem to be this species were collected from the following localities, the most important variations are noted with each one. Indian Hill, Claremont, California. The head is moderately supplied with simple short hairs. The first segment dorsally has about ten hairs in a single row. The second segment has about 26 hairs. The last segment has about 12 hairs. The antennæ bear short hairs. The cerci have many moderately long hairs and the terminal part has seven cross striations. The terminal spine is short. There are 19 joints in the antenna and the total body length is 3 mm.

South Hills, near Pomona, California. There are about 20 hairs on the dorsum of the head, six on the first body segment, about 17 on the second scutum. Some of the basal leg appendages are conical, some are blunt. The Cerci bear rather short moderately heavy terminal spines. There are 21 joints in the antenna and the length is 4 mm.

Temiscal Canyon, California. There are rather fewer hairs on the dorsum than in some. The eye area is circular. The cerci are clothed in rather short hairs.

Corona, California. In a small canyon two miles west. The claws on the second pair of legs seems slightly uneven. On most of the legs the claws are even. Antennal joints 14, total length, 1.6 mm.

Symphylella santa n. sp.
(Figs. 5a, b, c, d.)

Length, 2.5 mm.

Head.—Length, .266; width, .200. There are about 26 hairs on the dorsum of the head and three hairs in the head triangle. The head rod is rather thick in the center, jointed behind where there are three branches, at its cephalic end there are branches at nearly right angles. The eye area is circular, .017 mm. in diameter.

Antennæ.—These are 17 jointed in the type with few rather long hairs on the basal segments. They do not form a whorl until the third segment. The hairs are shorter than the segment to which they belong in the first and second segments. The hairs are longer than the segment in the third and others. The tip segments have very short hairs and several small sensory pits.

Scuta.—The first segment bears four hairs, the second about 14 hairs. Their sizes and proportions are about as in other specimens described from the island, but a distinctive feature is found in the fact that between the second and third, between the third and fourth, between the 6th and 7th and possibly some other segments there are especially long lateral setæ not arising from the scuta but between them and extending latero-ventrally. The dorsal scuta are rather large and rather broadly pointed.

Legs.—The first to the third legs are .152 mm. long, the fourth and fifth are .171 mm. long, the sixth .19 mm. long. The last legs are .266 mm. long. The last leg is provided with four hairs on the third leg segment two of which are dorsal. The fourth joint has about four cephalic hairs or about 7 in all. The last segment has at least three dorsal hairs. On the first foot and that of several others at least and including the last there seem to be three claws because of a short, rather heavy apical spine or hair. Basal processes were not noted on the legs.

Cerci.—These were .048 mm. wide and .228 mm. long. The hairs are rather irregular in about five whorls. They are also rather short. The cross lines near the tip are as usual and the terminal spine of moderate length.

Terminal Sense Hair.—This is on a well-developed lobe with two rather long hairs in addition to the longer terminal hair of the knob.

Locality and Material.—From Santa Cruz Island north of Pelican Bay.

Distinguishing Characters.—The long lateral setæ between some of the segments is especially remarkable. The apparent three-clawed condition of some at least of the feet is important. The head rod is of a distinctive type.

Symphylella brevipes Hansen.

Specimens from the following localities although differing in minor details seem to be of the above species.

Glen Ivy, about 50 miles from Claremont. The head bears about 32 hairs above. There are two hairs in the head triangle. The first dorsal plate has 8 hairs, the second 14 hairs. The head rod has a few small branches at its upper end and is forked behind with a small knob between the forks. The basal appendages are small and conical. There are 18 antennal joints. The total body length is 2.2 mm.

Big Pines, Mountains near Claremont, 7,000 feet elevation. The head has 24 hairs above. The head triangle has three hairs. The first segment above has six hairs. The second scutum has 14 hairs. Joints of the antennæ 15. Total length, 2.25 mm.

San Jacinto Mountains, Strawberry Valley, 7,000 feet elevation. Head above 32 setæ. Head triangle, 3 hairs. First thoracic segment has six hairs above. The second scutum has 18 setæ. The eye area is circular. All legs have two equal claws. Joints of antennæ, 18-24. Body length, 1.5 mm.

Mexico Valley. In some the head rod is wavy. The basal leg appendages are evident and usually truncate with at least one rather sharp spine at the end. The head triangle has no hairs. The ocelli are twice as wide as long. Sixteen to 19 joints in the antennæ. Lengths, 2 to 3 mm.

Cuba, 20 miles from Havana. Head rod simple as far as seen, claws even, rather hairy legs and body, all legs 2 equal claws. Antennæ, 15 joints. Length, 2 mm.

Cuba, near Matanzas. The last three legs seemed to have the claws somewhat uneven but all the rest seemed as usual. There were fewer hairs evident on the body than in the last. The ocelli are circular in outline. Seventeen joints on the antennæ. Total body length, 2 mm.

Symphylella cubæ n. sp.

(Figs. 6a, b, c, d, e, f, g.)

Length, 2 mm.

Head.—Length, .2125 and width, .153 mm. The head rod is long and slender and seems unbranched forward but with three branches caudally, the central portion being thick and branched again. There are about 14 hairs on the head above. The ocellar area is circular and .02125 mm. in diameter.

Scuta.—The first body segment is rather longer than usual with about 10 setæ. The second scutum with its sharp points is possessed of about the same number of setæ.

Legs.—The first leg is .15 mm. long. The second leg is .539 mm. long. Several other legs are of about this length. The legs gradually increase in length and the last leg is the longest at .25 mm. long. The claws on the legs seem even or nearly so. The last leg has three cephalic spines or hairs on each of the last two joints. The second joint has two ventral hairs, the third joint has three prominent hairs. All the legs as far as could be learned possess a rather thick basal lobe which bears rather strong hairs. The basal appendage of the first leg bears 6 hairs. The appendage of the second leg bears 10 hairs, that of the third three large hairs and 16 minute hairs. The fourth bears 4 large hairs and many small ones. The fifth leg has 6 large hairs on its appendage. The sixth leg has four large hairs on its appendage. The eighth has 5. The appendage of the last leg has five marginal hairs coming from as many little serrations of the appendage.

Antennæ.—18-jointed. The basal segments have hairs about as long as they are in a single irregular whorl for each joint. The terminal joints have small sense pits and the tip joint is lobed and covered with fine hairs on its apex.

Cerci.—These are .1539 mm. long and one-fourth as broad at the base. The terminal region has about eight transverse striations and the terminal spine is about equal to the breadth. It is pointed but thick at the base in the type.

The Terminal Sense Hairs.—These are located in rather long lobes. One short hair is near the base of the large hair and several others near the body of the animal.

Locality and Material.—Artesia, Cuba. A number of specimens were collected. These and the type are in the Pomona College collection.

Distinguishing Characters.—The basal appendages of the legs are of a peculiar type. The head rod is rather distinctive. The last joint of the antennæ is peculiar.

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EXPLANATION OF PLATE.

FIG. 1. *Pseudoscutigerella americana* n. sp. (a) Side view of cercus and associated parts. (b) Last leg.

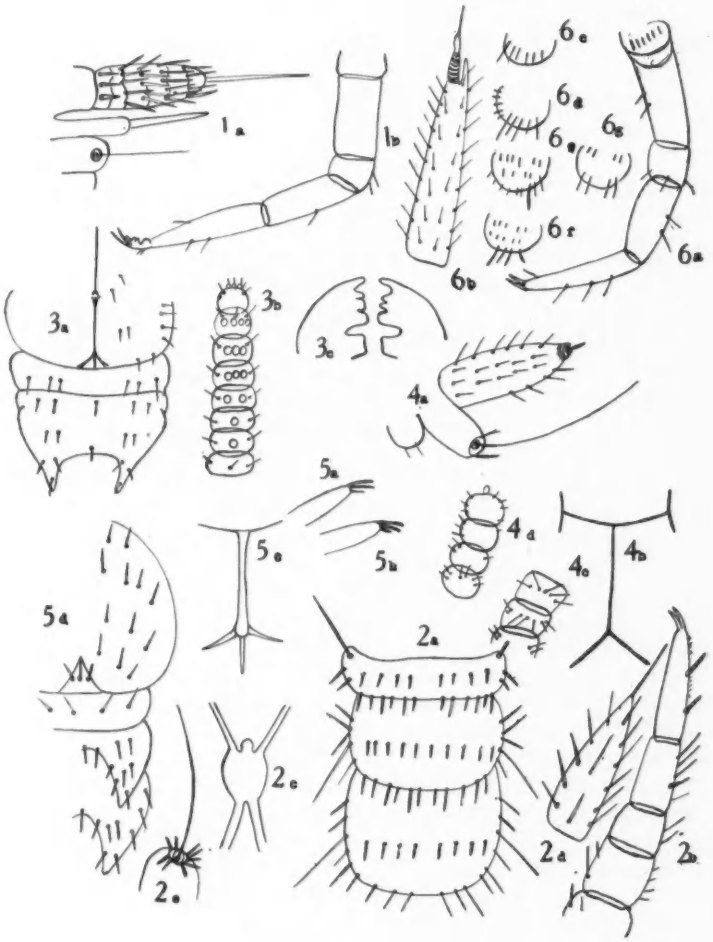
FIG. 2. *Hansinella californica* n. sp. (a) First three thoracic plates from above. (b) Last leg. (c) Central part of head rod. (d) Cercus.

FIG. 3. *Scolopendrellopsis sensiferis* n. sp. (a) Head and head rod with first two segments of the body from above. (b) Last joints of an antenna. (c) Jaws.

FIG. 4. *Scolopendrellina californica* n. sp. (a) Lateral view of the cercus and associated parts. (b) Head rod. (c) Basal segments of antenna. (d) Tip segments of antenna.

FIG. 5. *Symphylella santa* n. sp. (a) Tip of first leg. (b) Tip of the second foot. (c) The head rod. (d) Lateral part of the head and the first three segments of the body.

FIG. 6. *Symphylella cubæ* n. sp. (a) Last leg. (b) Cercus. (c) Appendage of the first leg. (d) Appendage of the second leg. (e) Appendage of the fourth leg. (f) Appendage of the fifth leg. (g) Appendage of the sixth leg.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ACROTOMOPUS ATROPUNCTELLUS BOH. IN ARGENTINA SUGARCANE.

H. A. JAYNES,
Associate Entomologist,
Bureau of Entomology, U. S. Department of Agriculture.

INTRODUCTION.

While searching for parasites of the sugarcane moth borer, *Diatraea saccharalis* Fabr., in Ledesma, Province of Jujuy, Argentina, on February 20, 1929, larvæ of a Curculionid were discovered within several cane shoots. On returning to Tucumán, four live specimens were turned over to the Tucumàn Experiment Station, and two were kept by the writer for rearing. On March 26, just a month later, the writer found a weevil borer in cane at the Tucumán Experiment Station which proved to be the same species as the Ledesma specimens. These were the first records of any such weevil occurring in sugarcane in the Provinces of Jujuy and Tucumán. Inasmuch as there are weevil borers doing considerable damage in South America and in other parts of the world, it was thought best to make further observations on this species.

From the larvæ collected in the cane, adults were reared and sent to Dr. Carlos Bruch at Buenos Aires, who very kindly tentatively determined these as *Archarias atropunctellus* Boh., having compared them with specimens in his collection named by Hustache as *Acrotomopus atropunctellus* Boh. Dr. Bruch stated that this species was originally described by Boheman[1] as *Cholus atropunctellus*, and that his specimens were obtained in Tucumán and Santiago del Estero on corn, being listed in his catalog[2] under *Archarias* Lac., having been determined as such by Dr. Heller from other specimens in Dr. Bruch's collection. Dr. Bruch further stated that in no case was it *Cholus*, but either *Acrotomopus* or *Archarias*. Dr. G. A. K. Marshall, who has examined the Tucumán specimens, places the species in *Acrotomopus*, where it doubtless belongs.

[1]Boheman in Schonherr, Gen. Curcul, III, 1836, p. 570.
[2]Bruch, Carlos, Coleoptera of Argentina, Part 7, 1915, p. 422.

DISTRIBUTION.

This weevil seems to be generally distributed throughout the cane-growing region in Argentina, as both larvæ and adults have been obtained from several different points. However, it has not been found in any great numbers except at Ledesma, Jujuy, and at Rio Chico, Tucumán.

EGG.

In only three instances were eggs of the weevil found; two of these were found on April 24, 1929, at Rio Chico, and the other one at Ledesma on January 10, 1930. These were found in small tender shoots of cane which had turned slightly brown and which had been punctured in three or four different places. Upon cutting open these cane shoots the eggs were found to be in the center of each shoot. The egg was creamy white and cylindrical, being about one millimeter in diameter. Those from Rio Chico were photographed the following day (Plate I, Fig. 4), and set aside for rearing. However, three days later the cane containing these eggs had become covered with a fungus and the eggs had disintegrated. The egg from Ledesma was broken in handling.

No other eggs were obtained, though several shoots of cane which showed injury by the adult weevil were examined from time to time. Several adults were placed in cages containing growing cane, but although all the shoots were punctured and later showed the injury characteristic of the weevil, none contained eggs or young larvæ upon examination.

LARVA.

The larvæ are found within the cane throughout the entire year, there being only one generation each year. The larva found on February 20, 1929, which was about half grown, did not produce an adult until eight months later, October 22, and those collected on April 24, the fall of the year, did not produce adults until November and December. The emergence from these larvæ, which were kept in the laboratory over the winter, was the same as from those larvæ collected in the spring which had wintered in the field, the majority emerging in November and December. The larvæ pass the winter in the lower portion of the shoot, going down two and three inches

below the surface of the ground in the stool of the cane, (Plate I, Fig. 3). It is often found that a larva has bored down one shoot and come up another, and sometimes the center of the stool has been considerably eaten. The number of molts that the larvæ pass through could not be determined as none was reared from the egg to the adult. There was a large variation in the size of the larvæ collected, and upon measuring the width of the head capsule of 23 larvæ there was a variation in size of from 0.09 millimeters to 2.25 millimeters. There appeared to be 6 distinct groups, the average of each being 1.0 mm., 1.3 mm., 1.55 mm., 1.75 mm., 2 mm., and 2.4 mm. There was very little difference in size of head capsule in any one group, but in size of body they varied from smaller than the preceding group to larger than the following group.

PUPA.

The larvæ transform to adults by passing to the pupal stage in the lower portion of the cane shoot, having first bored a tunnel to the outside of the cane so that when the adults have formed they can escape. Of those larvæ kept in the laboratory, two required 14 days from the time the pupa was first formed until the adult emerged, while a third required only 7 days.

ADULT.

The adult weevils obtained by the writer ranged in length from 10 to 14 millimeters, being a light dull granulated brown color. (Plate I, Figs. 1 and 2). The technical description by Boheman follows:

"*Oblongus, niger, albido-squamosus, thorace anterius minus angustato, punctato, remote granulato, utrinque in medio dorsi leviter impresso, basi sub bisinuato, elytris subtiliter punctato-striatis, interstitiis remote nigro granulatis.*

Habitat in America meridionali. A Dom Ménétriés missus. Mus. Schh.

Reliquis angustior, sub-cylindricus. *Cholo pistori* fere aequalis, sed duplo fere angustior. Caput mediocre, rotundatum, nigrum, squamulis albidis remote, supra oculos dense obsitum; vertice remote subtiliter, fronte profundius punctatis, oculi ovati, transversi, haud prominuli, nigri, rostram longitudine capitis cum thorace, deflexum, minus crassum, teres, arcuatum, apicem versus nonnihil ampliatum, nigrum, sub-nitidum, basi carinula abbreviata instructum, undique sat crebre punctulatum. Antennæ mox pone medium rostri insertæ, tenues, nigro-piceæ, albido-pilosæ, clava parva, oblonga-ovata, dense

cinereo-pubescente. Thorax latitudine baseos vix longior, apice truncatus, anterius parum angustatus, lateribus modice rotundato-ampliatus, basi leviter bisinuatus, angulis baseos retrorsum nonnihil prominulis, supra parum convexus, minus crebre punctatus, granulis remotis, nigris, denudatis, adspersus, in medio dorsi utrinque foveola parum profunda impressus; totus niger, squamulis dilute paleaceis tectus. Scutellum parvum, rotundatum, nigrum, punctulatum. Elytra subobconica, basi conjunctim introrsum leviter emarginata, antice thorace fere angustiora, quam lata triplo longiora, humeris vix prominulis, fere rectangulis, a basi apicem versus perparum sensim angustata, apice ipso conjunctim obtuse rotundata, supra modice convexa, ante apicem gibbere obtuso notata, regulariter, etsi subtiliter, punctato-striata, interstitiis planis, remote seriatim nigro granulatis; tota nigra, squamulis unicoloribus paleaceis dense tecta. Corpus subtus nigrum, squamulis albidis sub-argenteis dense vestitum. Pedes elongati, nigri; anticis longioribus; squamulis albidis adspersi; femoribus modice clavatis, subtus ante apicem dente parvo, oblongo, armatis; tibiis nonnihil arcuatis, apicem versus ampliatis; tarsis dilatatis, subtus fulvo-spongiosis.—B.H.N."

During the season of 1929 and 1930 the first weevils probably appeared in the field during the middle of November, according to the rearing records, but the first adults were not found until December 6, at Rio Chico. On this date not an adult was found from 11 A. M. to 2 P. M., although sweepings were made, the cane carefully searched, and several injured shoots cut open for examination. However, from 2 P. M. to 3 P. M., six adults were found either sitting on the leaf in plain view or down in the sheath next to the stalk.

On December 9 one adult was found on cane near Ingenio San Felipe, Tucumán, and on December 14 another was found near Ingenio Concepción, Tucumán, but at Ledesma on January 10, 1930, 24 adults were found in the cane within one hour. These were all located within one field. There were eight found in pairs of two, the others being collected as individuals, except in one case where there were four found all on the same cane sheath.

The adults play "dead" or "possum" when disturbed, often dropping to the ground, and are then hard to see owing to their brown color. They also go down between the leaf sheath and stalk, being almost entirely out of sight. It was observed from those kept in cages for experiments that they went down into the cracks in the soil. In one case where an old hollow stub of cane was in a cage, three adults were found in it on examintation.

INJURY.

The adults kill a large number of the young cane shoots by puncturing them for food. These are small, rough-edged punctures and are distinctly different from a Diatraea borer hole. The shoots that have been punctured for food, and also those containing young weevil larvæ, become brown and die. The outside leaves become dry as well as the center leaves, thus distinguishing this injury from the characteristic "dead-heart" injury of the Diatraea borer, which at first turns yellow only in the center.

The number of shoots injured by the weevil in obtaining food is more noticeable earlier in the season (the first part of December) than later. This is due to the fact that the young side shoots punctured early in the season turn brown and die, while later they have fallen amongst the trash and are not noticeable. Also, later in the season the side shoots are larger and stronger and do not turn yellow unless considerably punctured or eaten by larvæ.

The weevil larva makes a large-size tunnel through the cane, leaving the burrow full of frass which makes it easily distinguishable from the tunnel made by a Diatraea borer.

In one field at Ledesma where there was a large infestation of the weevil, the upper part of the cane looked green and healthy at a distance, but upon closer examination the lower half appeared to be drying up for lack of water. This drying was due to the fact that about 40 per cent of the side shoots contained larvæ of the weevil. These shoots were at this time about three quarters of an inch in diameter and from two to three feet high. At another time, upon examination of ten stools in one row of cane, 16 weevil larvæ were found, and several of the side shoots showed injury but contained no larvæ.

Two larvæ have been found in the same shoot, but inasmuch as they are of cannibalistic habits, and the tunnel occupies most of the space in the smaller shoots, there is not room for more than one, and the larger or stronger usually eats the others that may occur in the same stalk. Two larvæ of the same size were found dead next to each other, each having been partially eaten by the other.

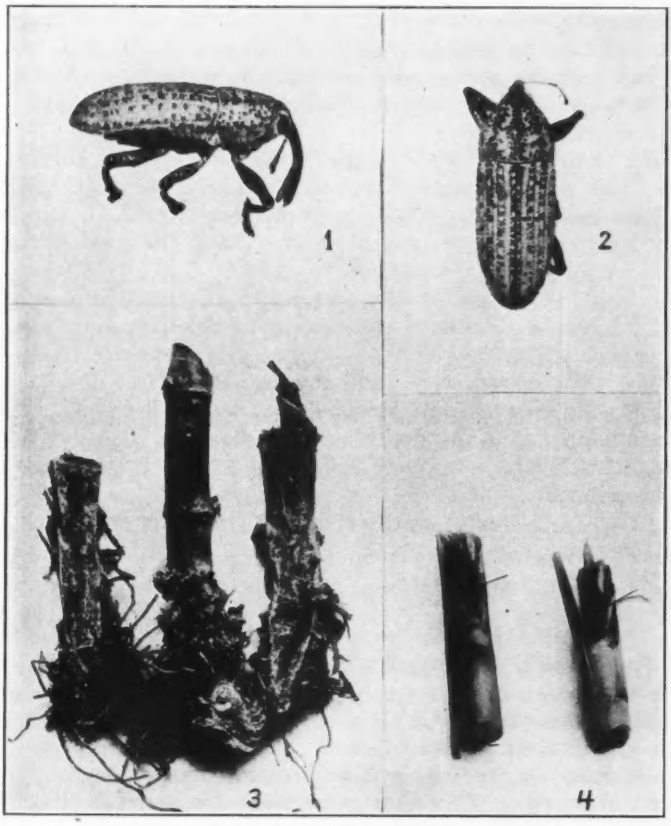

Fig. 1. Lateral view of adult of *Acrotomopus atropunctellus* Boh.
Fig. 2. Dorsal view of adult of *Acrotomopus atropunctellus* Boh.
Fig. 3. Larvæ of *Acrotomopus atropunctellus* Boh. during hibernation in root of sugar cane.
Fig. 4. Egg stage of *Acrotomopus atropunctellus* Boh. in center of sugar cane plant.

PARASITES.

From 19 weevil larvæ that were cut from young cane shoots on April 24, 1929, at Rio Chico and placed in individual pieces of cane for rearing, two fly puparia were obtained. One of these puparia was formed by May 23, while the other was not formed until October 8, the adult of which emerged on October 26, 1929.

On October 22, while again looking for weevil borers in Rio Chico, 16 live borers, 1 good fly puparia, and 2 empty fly puparia were found. These puparia were found in tunnels previously made by the weevil borer. From the good puparia the fly emerged on November 7.

It will be seen that the percentage of parasitism in the first lot was 10.5 and in the second lot 14.7, or an average parasitism of 12.6 per cent.

The flies reared were sent to Dr. Aldrich, of the U. S. National Museum, who kindly determined them as *Paratheresia claripalpis* Van der Wulp. This is the same fly which parasitizes *Diatraea saccharalis* Fabr. to such a large extent in both Argentina and Peru[3].

This was the only parasite found attacking the weevil larvæ, and so far no indications of any other parasite have been found.

ECONOMIC IMPORTANCE.

There is a possibility of this weevil increasing in sufficient numbers to cause noticeable damage to the cane, such as was seen in Ledesma and Rio Chico. An extremely heavy infestation of weevil larvæ would cause considerable damage to the cane stools over the winter, and also to the young cane shoots in the spring. As the weevil appears to be widespread throughout the sugarcane region of Argentina and so far has done damage only in small localities, it may be that it is more or less controlled by its parasites. However, it should be watched to determine whether or not its increase is general or only spasmodic.

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[3]Jaynes, H. A. Notes on *Paratheresia claripalpis* Van der Wulp, a Parasite of *Diatraea saccharalis* Fabr. Jour. Econ. Ent., Vol. 23, No. 4, August, 1930, pp. 676–680.

PRELIMINARY STUDIES OF THE INTERNAL STRUCTURES OF BRAULA COECA NITZSCH.*

ERWIN C. ALFONSUS AND ERDMAN BRAUN,
Division of Entomology and Economic Zoology,
University of Minnesota.

INTRODUCTION.

The first mention of this insect was made in 1740 by Reamur (9), who discussed its relation to the honeybee. Nitzsch (1818) described the genus and species, naming the insect *Braula coeca;* and classified it, on account of its mouth parts, with the Diptera, associating it with the Pupipara. Errors in Nitzsch's description of antennæ and thorax were corrected by Egger (4), thus removing any doubt as to the alliance of Braula with the Diptera. Since Braula did not fit into any insect classification then in use, Egger proposed the special family, Braulidæ. According to Muggenberg (7), the structure of the head vesicle shows a close relationship between Braula and the Hippoboscidæ. Taxonomically, Handlirsch (5) removed the Braula from the Pupipara and placed it in a separate family next to the Phoridæ. It was formerly generally believed that *Braula coeca* was pupiparous but, according to Muggenberg (7), Skaife (10), Arnhart (2) and Argo (1), it is oviparous. Skaife and Argo described fairly completely the life cycle of the insect, while Arnhart found the mines and dried out larval skins under honey cappings. Perez (Phillips 8) found that Braula was not a true parasite, as believed by the older workers, but that it was a sort of commensal parasite feeding on the nectar which it steals from the honeybee. Muggenberg (7) described the mouth parts and discovered the eyes of the supposedly blind insect in 1892. Borner (3) gives a detailed account of the external morphological structures. Skaife (10), through microdissection studies, described in a general way the alimentary canal and the male and female reproductive organs. He also worked out the metamorphosis of this insect.

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MATERIAL AND METHODS.

The specimens of *Braula coeca*, preserved in 70 per cent alcohol, were obtained from Mr. Oswald Muck of Vienna. They were gradually changed from 80% to 95%, and finally, for dehydration, to 100% alcohol. They were then cleared in Xylene. Paraffin, at a melting point of 54-56° C., was used for infiltration and imbedding. The sections were cut at 7 microns. Half of the serial-sections was stained in Mayer's Haemalum and counter-stained in aqueous eosin, the other half was stained in Iron Haematoxylin and counter-stained in aqueous eosin.

Sectioning of the heavily chitinized insects was carried on with difficulty, the brittle chitin shattering on the edges, giving a distorted view of some of the internal parts close to the chitin. Sometimes entire sections shelled out. Two series, out of the 16 sectioned, were complete. The remaining series, although incomplete, afforded checks on various details of the structures which had to be determined.

THE BODY-WALL AND ITS APPENDAGES.

The body-wall of *Braula coeca* consists, in the outer part, of a heavily chitinized cuticula, interrupted only at the movable joints by a soft intersegmental membrane. The cuticula is made up of two main layers—the outer, harder layer or the primary cuticula, and a softer, inner layer or secondary cuticula. The cuticula varies greatly in thickness, approaching its maximum density around the epicranial capsula and the dorsal part of the mesothorax. Heavily chitinized invaginations, e.g. the ptilinum, or the openings of the genitalia, have a modified cuticula bearing numerous soft spines which give to it a furry appearance.

Practically every part of the body is covered by sensory hairs of varying lengths and diameters, which are inserted in sockets and joined to the cuticula in such a manner that they are movable. These sensilia originate from an inervated hypodermal cell and are hollow nearly to the tip (Fig. 1).

The hypodermis consists of a single layer of somewhat flattened cells which are evenly distributed over the entire body-wall. These hypodermal cells are distinctly nucleated, the nuclei being oval in shape and staining fairly well.

The basement membrane, underlying the hypodermis, is a thin, structureless sheath, interrupted only by the muscle insertions and by the nerve-fibres leading to the sense organs.

The pulvilli of Braula are located at the terminal point of the last tarsal segment, above the comb-like arrangement of claws. When walking on a smooth surface the insect turns the claws inward, thus gaining the full use of the pulvilli. The cuticula of the pulvilli is interrupted by many hollow tenent hairs, each of which connects at its base with a gland cell. At the distal end of each tenent hair a minute, bladder-like organ may be seen (Fig. 10).

MUSCLES AND ENDOSKELETON.

The muscles of *Braula coeca* are all of the striated type. Every muscle fibre represents a compound cell with many strongly-staining nuclei. These muscles are attached to the body-wall by interlocking with the hypodermal cells (Fig. 2) or epithelial cells at invaginations (Fig. 3).

No sign of an endoskeleton was found in the head or dorsal half of the thorax of this insect. In the median line of the ventral surface of the thorax arise the furcæ, heavily chitinized plates, which join each other to form a ridge. This ridge approaches very close to the thoracic ganglia, extending almost through the entire length of the thorax. Lateral apodemes arise between the coxæ and join the furcæ, forming partial cross-plates. The furca widens and reaches its greatest thickness just behind the metathoracic ganglion, on the ventral side of the connective, which extends to the abdominal ganglion. This endo-thoracic projection serves for muscle attachment.

THE NERVOUS SYSTEM.

The nervous system of Braula (Fig. 7) consists of the brain, the sub-oesophageal ganglion, three paired and closely united thoracic ganglia, one abdominal ganglion, and the connectives between these.

The supra- and sub-oesophageal ganglia appear as a mass through which the oesophagus passes. From the supra-oesophageal ganglion extends:

1. The optic nerve, which is very thin, leads to an inconspicuous eye, which was first discovered by Muggenberg (7). At the terminal point of the optic nerve, very slightly different

from the hypodermal cells and protected by a cuticular invagination, there is a group of cells, arranged radially, which constitute the internal eye. Apparently there is a dark substance present among the optic cells, which may be pigment. The eye is visible externally, just above the antennæ, as a pale spot on the cuticula, surrounded by a more darkly pigmented chitinous ring.

2. The heavy antennal-nerves also start from the supra-oesophageal ganglion and they branch immediately after entering the antennæ.

3. Another pair of nerves from this ganglion inervates the labium.

The suboesophageal ganglion sends out only two pairs of nerves—both of them large—the maxillary and the labial nerves.

The ganglia, when sectioned, are finely granulated and are surrounded by small cells with darkly staining nuclei. This surrounding layer of cells varies in thickness.

Slightly above the oesophagus, there extends forward from the brain two thin, arched nerves which meet and form the *frontal ganglion*. From the frontal ganglion a single unpaired nerve extends backwards along the oesophagus and finally terminates at the mid-intestine.

The connectives (Fig. 7) leading from the suboesophageal ganglion through the cervical region into the thorax, are so closely approximated as to form a cord. Here it enters the thoracic ganglion mass. From the lateral sides of each of these three thoracic ganglia, the most conspicuous structures are a pair of large nerves leading ventrally, each pair entering a pair of legs. From the caudal end of the thoracic ganglionic mass, a stout and short connective leads into the abdomen.

The abdominal ganglion is unpaired and sends out several branches. The hind-most, and largest pair of these branches terminates in the reproductive organs.

Numerous small branches originate from the various ganglia that inervate the sensory hairs on the body periphery (Fig. 7) and the closing-apparatus of the spiracles. Other branches lead to the secretory and excretory organs, as well as to the heart, the intestines and the muscles.

THE ALIMENTARY CANAL AND ITS APPENDAGES.

Skaife (10), through a binocular dissection study, determined the divisions in the alimentary canal, and illustrates them with a series of drawings.

Fore-Intestine.—The mouth of *Braula coeca* consists of a heavily chitinized invagination that gradually narrows down to the pharynx. The pharynx extends upward as high as the antennal cavity turns towards the anterior wall of the head (Fig. 5), then slightly downward and then suddenly upward, running a short distance along the body-wall, to which it is attached by muscles. A posterior turn leads the oesophagus between the supra- and sub-oesophageal ganglia into the thorax, where it widens and divides into two passages, one leading into the crop, the other through the proventriculus, into the mid-intestine.

The crop (Fig. 5) is a large, thin-walled vessel which fills the major part of the abdominal body-cavity. It represents a food reservoir of vast capacity.

The oesophagus extends forward, within a short distance of the mid-intestine, loops backward for a short distance, gradually thickening in size, then loops forward, tapering down and bending in such a manner that the loops form the proventricular valve. The mid-intestine begins at the posterior end of the proventricular valve.

The layers of the fore-intestine are:

1. The Intima. Starting as a chitinous layer of considerable density, it gradually becomes thinner to form a fine membrane in the oesophagus. As crop-lining, it is so thin that it can only be observed with difficulty (Fig. 4).

2. The Epithelium. From the mouth, through the pharynx and oesophagus, the epithelium consists of flat, cuboid cells with oval, well-staining nuclei. These cells gradually flatten out in the oesophagus to a point where the cell-dividing membranes disappear. The epithelial cells of the crop-wall are depressed to such an extent that the nuclei are spaced a considerable distance apart. In the proventriculus, the epithelial cells attain their greatest dimensions and have large circular, strongly-staining nuclei. The cytoplasm of the epithelium of the proventriculus also takes the stain readily, showing a fine granulation.

3. The basement membrane. This underlies the epithelium, and is a continuous, nearly structureless, layer, closely resembling the basement membrane of the body-wall. The basement membrane is so reduced in the crop that it can barely be differentiated from the longitudinal muscle layer.

4. The muscle layers. These lie next to the basement membrane and are in two layers, one longitudinal, the other circular. Both of these muscle layers are well developed in the pharynx and in the anterior end of the oesophagus. After the oesophagus passes the brain, they are much reduced in size. Around the crop both the longitudinal and circular fibres are spread apart, producing, thus, a net-like structure. There is a considerable increase both in number and in size in the fibres of the two muscle layers around the proventriculus. This is probably due to the necessity for musculation of the proventricular valve.

The intestinal muscles are striated. They show the same staining properties as the other muscles, but are not as regularly nucleated. The nuclei are oval in shape, very small, and present a group of two or three chromatin granules. These characteristics of the intestinal muscles apply to all the regions of the alimentary canal.

4. The peritoneal membrane. This is a thin structureless layer, which is penetrated only by air-supplying trachea and nerves and which envelopes all parts of the intestines.

Mid-Intestine.—The mid-intestine extends from the oesophageal valve to the place where the Malphigian tubules enter. The wall is of considerable thickness, having frequent transverse infolds. The mid-intestine is made up of the following layers: A digestive epithelium, with dark staining-plasma and large circular nuclei. The nuclei have numerous small chromatin granules. The cell-walls, however, are indistinct, probably due to fixation methods (Fig. 8). Underlying the epithelium is the basement membrane. This is followed by two layers of muscles, which are surrounded by a peritoneal membrane.

The muscle layers of the mid-intestine differ from those of the fore-intestine by their reversed position. There is a circular layer surrounded by a longitudinal layer. A thickening of these muscles, and more compact arrangement, can be observed where the mid-intestine narrows down at the junction with the hind-intestine.

Malphigian tubules.—Skaife (10) found four Malphigian tubules in *Braula coeca*, two on each side pairing to form a single tube before they enter the hind-intestine. The same arrangement was found in other Diptera (Hewitt's (6) description of *Musca domestica*). These tubules are long and slender, winding their way around the viscera. They are found in almost any position in a section, e.g. along the side of the heart, close to the genital organs, on both sides of the mid- and hind-intestine. In one section, due to their convolutions, eleven cuts through these vessels were counted. The tubes are of uniform thickness from their starting point to their blind ending, no reduction in the diameter taking place after the branching. There are only two distinct layers visible, an epithelium and a surrounding membrane (Fig. 6). no sign of an intima was observed. The Epithelium consists of a layer of large cells with indistinct cell wall. In only a few cuts were these cell walls visible. The cells are of such dimensions that only two or three are visible in a cross-section through a tubule. The cytoplasm of these cells shows a variety of staining reactions, as though the cells were in a different state of function or development. The dark-staining nuclei have a swollen, succulent appearance. There are visible, in each nucleus, one or two large granules of chromatin and many smaller granules. The tubules are enclosed by a thin, well-stained, structureless membrane. The lumen is continuous, its size varying in accordance with the size of the epithelial cells. No muscles, whatever, were visible on the Malphigian tubules.

Hind-Intestine.—Braula coeca, unlike most other insects, does not show any regional divisions of the hind intestines. Starting from the narrow restriction, at the mouth of the Malphigian tubules, the hind-intestine suddenly enlarges and shows no further restrictions until it narrows down to form the anus (Fig. 5). The hind-intestine is lined by an intima which is continuous with the cuticula at the anal opening. Outside of this is an epithelium with indistinct walls, apparently a syncytium. The plasma of this epithelium exhibits fine granulation which does not stain as well as it does in the fore- and mid-intestine. The epithelial nuclei are far apart, of small size and strongly stained. There is an evident thickening or swelling around these nuclei, thus rendering the intima tuberculate in appearance (Fig. 9). The epithelium is lined by

a basement membrane, next to this are the three muscle layers: First, the ental-circular muscle layer; then the longitudinal muscle layer; and, finally, the ectal-circular muscle layer. The arrangement of these muscle layers is of a peculiar type. The two circular layers are so similar that it would be impossible to distinguish them from each other, if it were not for the longitudinal muscles interspaced between them. The peritoneal membrane encloses the entire hind intestine.

Skaife (10) observed, in the hind-intestine of *Braula coeca*, four rectal glands, all well supplied with tracheæ. These are similar to the findings in other Diptera, i.e. Hewitt (6) in *Musca domestica*. These four glands are circularly arranged in the anterior part of the hind-intestine. They are attached to the wall and hang into the lumen of the intestine. Each gland has a circular base and exhibits a pouch-like shape. Externally there is a perforated chitinous layer which is continuous with the intima of the hind-intestine. The cavity of the glands is filled with loose, branching cells (Fig. 5). Every one of these cells has a large nucleus with one or two large, well-stained chromatin granules. There is visible, at the base of each gland, a mass of cells with smaller-sized nuclei, and without any distinguishable cell membranes. The lumen opens into the intestine through the perforations in the chitinous membrane. The cytoplasma of the gland cells shows a fine granulation and large vacuoles. The tracheæ entering the glands, send out branches which penetrate the cell membranes.

Salivary Glands.—One pair of salivary glands is present in *Braula coeca*. This pair is situated in the thorax, one gland on the left and the other on the right, slightly posterior to the proventriculus. The salivary gland of this insect represents a spindle-shaped arrangement of glandular cells, enclosing a lumen (Fig. 11). A duct extends ventrally from the lumen, joining the duct of the other gland ventrad of the connective and cephalad of the prothoracic ganglion. The single duct proceeds, from the point of junction, in a cephalic direction, and passes through the cervical region (Fig. 5), where it turns ventrad and extends along the sub-oesophageal ganglion. The salivary duct thickens, as though it is forming a reservoir, after it enters the head. The duct narrows again, after entering the labium, bends slightly forward and opens, from the lower part of the labium, into the mouth.

Each salivary gland consists of a single layer of glandular cells, circularly arranged around the lumen. They are elongated cuboid cells with dark-staining nuclei, of a swollen and succulent appearance (Fig. 11). The nuclei vary from circular to oval in shape. The cell walls are very distinct. The cytoplasm is strongly granulated and takes the stain readily on the free edge of the cells, the color gradually becoming more faint as the lumen-edge is approached. A structureless basement membrane surrounds the gland and continues to envelope the duct. No chitinous structure, underlying the glandular epithelium, could be observed. The salivary duct, the paired ducts, and the single duct each consist of three layers: A chitinous layer, modified like a spiral taenidium (Fig. 11), lines the interior of the duct. This structure is very similar to the taenidium of a trachea but lacks the spiny projections which are characteristic of the tracheal taenidia. The next layer is the much-flattened epithelium, with small nuclei spaced far apart. No distinct cell walls could be observed. A basement membrane surrounds the entire duct.

RESPIRATORY SYSTEM.

The number, and the location, of the spiracles in *Braula coeca* have been discussed and illustrated by Borner (3). The male and female have the same number of pairs, namely: 5 abdominal, 1 meta- and 1 meso-thoracic. The five abdominal spiracles are situated on the last five oblique pleural plates of the abdomen. The meta-thoracic spiracle is on the posterior narrow edge of the meta-sterum. The meso-thoracic spiracles have moved dorsad so far that they are visible, not only laterally, as circular punctures, but also dorsally as semi-circular indentations, on the edge of the ventral mesonotum. The abdominal and meta-thoracic spiracles are small and inconspicuous. The spiracles are surrounded by a circular peritreme.

A cross section through a spiracle (Fig. 12) shows that the peritreme covers a tiny vestibule with smooth chitinous walls which are directly connected with the cuticula. The exterior end of the vestibule is closed by a thin, chitinous plate, which has a slit in the center. The slit ends overlap each other to form a trap-like opening. A second chitinous ring, with a small opening, is situated at the interior end of the vestibule. The slit in the second ring leads into a second chamber, whose wall is densely covered with fine hair. At the interior end of

this second chamber is a third ring and closing apparatus. The tracheæ lead inward from this second vestibule. A muscle and nerve fibre are attached to the closing apparatus. The spiracular invagination is lined with an epithelium which is supported by a basement membrane. These layers are continuous with the lining in the tracheæ.

The mesothoracic spiracle is much larger in size than any of the other spiracles but it is not surrounded by a distinct peritreme (Fig. 14). A large, circular opening leads into a large, round vestibule. Many hairs project inward from the chitinous walls of this vestibule, thus forming a hair-filter. At the inner end of this chamber are two chitinous rings, a small and a large one respectively, having circular openings in the center. These openings lead into a smaller, cyclindrical chamber, which has smooth chitinous walls and which widens at the end where the closing apparatus is situated. A nerve and a large transverse muscle control the functioning of the closing apparatus. The trachea leading away from this spiracle into the interior part of the body, has about three times the diameter of the tracheæ of the other spiracles.

A trachea is made up of three layers: 1. A chitinous taenidium, spirally arranged, sending out spine-like projections in a radial arrangement towards the center of the tube (Fig. 20); 2. An epithelium, which surrounds this taenidium and consists of much flattened cells with round and flat nuclei; (The nuclei contain two or three chromatin granules. The plasma in the epithelial cells stains very slightly and has a homogenous appearance. One cell may circumferentiate a tracheal cross section) 3. and finally, a structureless basement membrane very similar to the one in the body wall.

The tracheæ leading into the body cavity branch immediately, the smaller branches passing directly to the various organs, the larger branches joining a main trunk that runs longitudinally through the body. This trunk reaches its largest dimensions in the thorax, at the junction with the extremely large trachea, coming transversely from the mesothoracic spiracles. Numerous branches from this pair of tracheal trunks provide an air supply for the various organs. These trunks extend into the head, passing the cervical region on the left and on the right of the ganglionic connective. In the head, these trunks divide into numerous branches, of various sizes, supplying air to the head regions.

THE HEART AND EXCRETORY ORGANS.

The heart of *Braula coeca* is a thin-walled, flattened tube, which extends from the beginning of the fifth abdominal segment to the thorax. It consists of five chambers and has four pairs of lateral openings (ostia). The wall of the heart takes a slight stain (Fig. 17). The first chamber is very short and is situated ventrad of the conjunctive of the fourth and fifth abdominal segment. It is a blind chamber, rounded at the posterior end. The other chambers are longer, adapting themselves to the length of the abdominal segments. The second, third and fourth chambers are similar in length and shape. There is a gradual reduction in width from the beginning to the center of each chamber and then gradually enlarging, until the infolding in the wall of the vessel forms an ostium, which structure marks the beginning of the following chamber. The fifth chamber is narrower and shorter than the previous ones, extending from the fourth pair of ostia to the caudal end of the aorta, approximately at the point where the thorax begins (Fig. 5).

Underneath the heart are a number of non-striated, slender, longitudinal muscle-fibres connected with each other by a fine, structureless membrane (Fig. 18). The course of the heart in the abdomen is not straight, slight convolutions occurring frequently. These convolutions are apparently caused by the pressure which is exerted against it by this filled crop.

The Aorta.—The aorta begins at the junction of the thorax and abdomen as a slender circular tube. It widens rapidly to form a thoracic ampulla, which bends ventrally (Fig. 5), narrows down, and, finally, is reduced to the normal-sized aorta. The aorta passes through the cervical region, above the oesophagus, into the head. In the head it turns dorsally, running close to the supraoesophageal ganglion until it reaches almost as high as the brain. The aorta opens, after a slight forward turn, very close to the brain.

The Pericardial Cells.—On both sides of the heart is a row of large cells. These are arranged in single-file formation, although occasionally a few of these cells bunch together (Fig. 17). In *Braula*, the pericardial cells are large and mononucleate. The nuclei vary from circular to oval. Others show a distinct bilobing (Fig. 19). The nuclei exhibit large, extremely dark-staining chromatin granules. The cytoplasm is granular

and vacuolated. The vacuoles show still finer granula. The nuclei are surrounded by an assembly of bodies, varying in shape, round or angular, which do not take any stain. These bodies, according to their location, appear black or yellowish-transparent. Between the pericardial cells, muscles and fat bodies, there are weakly staining fibres.

The Fat Bodies.—Fat bodies, varying in size, appear in all parts of the body. In general they are directly beneath the hypodermis and appear much flattened. Lobes, varying in dimensions and shapes, surround most of the organs. The fat bodies assume the form of the space available. The abdomen, with the exception of the dorsal surface, contains few fat cells, due to the fact that intestines and the genitalia fill nearly the entire body-cavity and leave very little room for adipose tissue. These fat bodies always contain two or more nuclei (Fig. 15). The dividing walls between the fat bodies are very indistinct. The nuclei are large in size and contain strongly-staining chromatin granules, of all sizes, loosely arranged. The cytoplasm shows fine granules, interrupted by numerous fat vacuoles, of varied shapes and sizes.

Oenocytes.—Oenocytes occur in various places in the body cavity in the same position as the fat bodies. Sometimes they are near the hypodermis and sometimes near the tracheæ. They appear to be closely associated with fat-cells, sometimes entirely surrounded by them. The oenocytes are found in groups ranging from two to eight. When they are not crowded, they are oval in shape, otherwise they assume the shape of the space available (Fig. 13, 16). The oenocytes are large, but do not approach the size of the nephrocytes. They have large, circular, very strongly staining, single nuclei, surrounded by more weakly staining, homogeneous cytoplasm. Binucleated oenocytes were not observed in *Braula coeca*.

THE REPRODUCTIVE SYSTEM.

Skaife (10) dissected the male and female reproductive organs of *Braula coeca*. He described and illustrated their outlines and external structures. However, he did not notice the bilobing of the testis in the male, neither did he find the accessory glands in the female.

The Male Organs (Fig. 22).—The male reproductive organs consist of a pair of ovoid, bilobed testes. The situation of the testes within the body cavity varies considerably. They lie

among the other viscera, surrounded by fat bodies; sometimes they are found in the dorsal half and sometimes in the ventral half of the body cavity. An individual, sectioned longitudinally in a plane parallel to the ventral surface, may show the right testis cut longitudinally through the center and the left testis not visible. In the same series, a section cut closer to the ventral side may show the left testis cut as a cross section, thus showing that this left testis is standing upright. The testes are found in the region of the second, third and fourth abdominal segment, laterad of the intestines. A slender tube, the vas deferens leads from each testis to a common ejaculatory duct. Slightly caudad from the point of union of the vasa deferentia, a pair of accessory glands joins the ejaculatory duct. The strongly-muscular ejaculatory duct extends caudally, with slight convolutions, from the entrance of the accessory glands to the penis.

The Testes.—The bilobed testes consist of two masses of sex cells. In some series, these cells were observed to be arranged in groups, in others they formed a homogenous cell mass, of uniform cells. Each lobe is surrounded by a tissue-like epithelial layer, (Fig. 22 t) in which no cell walls are visible. The nuclei are large and enclose several strongly-staining chromatin granules. There is another membrane next to the epithelial layer, which encloses the entire testis. This peritoneal membrane takes the stain sparsely. The nuclei are visible in the membrane but are some considerable distance apart. No sign of a cell formation is evident.

The Vas Deferens.—There are only two layers in the vas deferens. The epithelial layer is made up of cone-shaped cells with faintly-staining, finely-granulated cytoplasm. The oval nuclei consist of many small, well-stained chromatin particles. A structureless basement membrane surrounds this epithelial layer.

The Mucous Glands.—The mucous glands, also, consist of only two layers; a glandular epithelium (Fig. 22 mg.), and an enclosing basement membrane. The epithelial cells are cuboid in form and resemble, in their cytoplasmic and nuclear structure, the secretory cells of the salivary glands. The nuclei stain deeply and have a succulent appearance. The surrounding cytoplasm is finely granular and stains deeply, becoming paler as it approaches the lumen. The cell walls are very distinct. A chitinous lining could not be observed in the gland.

The Ejaculatory Duct—The ejaculatory duct consists of seven layers. The first is a chitinous intima which lines the lumen of the duct. The next is an epithelial layer with numerous infoldings (Fig. 22 ed.). Distinct cell walls were not observed in this layer. The nuclei are of moderate size and well stained. The cytoplasm stains weakly. A basement membrane surrounds the epithelium. Three layers of muscle surround the duct and these are lined by a peritoneal membrane. There is first a weak inner layer of circular muscles, followed by a layer of longitudinal muscles and these are surrounded by an extremely strong layer of circular muscles. These muscles are nucleated and stain fairly well.

The Female Reproductive Organs, (Fig. 21).—The female reproductive organs consist essentially of two ovaries, each divided into a pair of ovarioles which are closely allied, and a short oviduct leading from each ovary to a common oviduct, or vagina. The vagina presents a large and strongly muscular structure (Fig. 21 v). A round spermatheca opens through a small duct into the vagina, posterior from the point where the two oviducts unite. There is, also, a pair of short, colleterial glands opening into the vagina. The strongly convoluted vagina extends to the genital opening, where a paired, short, blunt and hairy ovipositor is visible externally. The egg-tubes project along the lateral walls of the abdomen, turning gradually dorsad (Fig. 21), their supporting ligaments being attached to the dorsal wall of the first abdominal segment. Fat bodies, as previously mentioned, surround the egg tubes. The single oviducts lead in a central dorsal direction and unite. The vagina extends gradually ventrad to the vaginal opening, which is on the ventral surface caudad of the eighth sternite.

The Egg Tubes.—An egg tube of *Braula coeca* consists of the following layers: 1. An epithelium; 2. a basement membrane; 3. a peritoneal envelope. The epithelium enfolds the oocytes and is described with the oocytes (Fig. 21). Underlying the epithelium is the basement membrane. The third layer, the peritoneal envelope, is continuous around both tubes, thus enclosing the entire ovary. Attached to the interior surface of the peritoneal membrane are a number of delicate, circular muscle fibres, spaced a short distance apart. The peritoneal envelope appears to be composed of several delicate, almost structureless membranes, with slight signs of nucleation.

A terminal filament, from the distal end of each ovary, attaches to the body-wall, serving as a support.

The germarium contains a mass of cells of varied sizes. The nuclei are indicated by strongly-staining, chromatin granules. There are generally four developing eggs in the vitellarium. The nurse cells present are not confined to the nurse chambers, as in other insects but are enclosed with the developing ova, within the same follicular epithelium. There is not even the slightest constriction of the follicle between the nurse cells and the ova. Ova and nurse cells, together, represent one large oval body. The nurse cells are extremely large and vary in shape, with large dark-staining nuclei, containing several large chromatin bodies. The cell walls are very distinct. The cytoplasm is well stained and heavily granulated. A finely granulated yolk-mass is visible in the lower part of the ova. This increases steadily with the ripening of the egg. As the yolk-mass develops, the size and number of the nurse cells decrease, until they become absorbed in the ripe egg. The epithelial cells of the follicle are cuboid in shape and their size increases with the size of the growing egg. Their plasma is well granulated and their nuclei consist of several small, well-staining chromatin granules.

The Oviduct.—The oviduct consists of an epithelial layer with numerous infoldings. The nuclei are large, circular to oval, and strongly staining. A basement membrane underlies the epithelium; and is surrounded by a very compact layer of longitudinal muscles, which, in turn is surrounded by a heavy layer of circular muscles. This circular layer appears to be made up of several smaller layers. A structureless peritoneal membrane is the last layer surrounding the oviduct.

The Spermatheca.—The interior of the spermatheca is lined by a chitinous intima. Following the intima is the epithelial layer, with large cuboid cells, having moderately sized nuclei, consisting of several small, well-staining chromatin granules. The cell walls are very distinct in the epithelium. A basement membrane surrounds the epithelial layer. The center of the spermatheca is filled with a fluid containing numerous spermatozoa. A section through the reservoir clearly shows tiny whirls. These indicate the movements of the sperms. The layers of the duct leading from the spermatheca to the vagina show the same characteristics as the wall of the spermatheca.

The Accessory Glands.—The small paired accessory glands have a structure very similar to the mucous glands of the male. No sign of an intima is evident. The glandular epithelium consists of a single layer of cells with oval dark-staining nuclei of a succulent appearance. The cytoplasma is roughly granular and strongly staining. The cell walls are distinct. There is a narrow lumen in the center of the glands which opens into the vagina.

The Common Oviduct or Vagina.—A chitinous intima constitutes the first layer of this duct. This intima thickens as the duct approaches the sexual opening and is continuous with the cuticula of the body wall. A strongly folded epithelium, with large distinct cells, is the next layer. These epithelial cells, with the exception of a few around the infolding are cuboid in outline. The nuclei are circular or oval and exhibit many well-stained, chromatin granules. The cytoplasm stains faintly, and has a homogeneous appearance. The epithelium is supported by a basement membrane. A layer of well-developed, longitudinal muscles follows the basement membrane. This layer of longitudinal muscles is surrounded by a multi-layer of circular muscles. A peritoneal membrane encloses all the layers. The muscles on the reproductive organs of the male, as well as of the female, show striation and are distinctly nucleated. The nuclei present a loose arrangement of well staining, chromatin granules.

SUMMARY.

The body wall is covered by a well-chitinized cuticula, penetrated by numerous sense hairs. The pulvilli are of a peculiar form, and function in the same manner as in other Diptera.

The nervous system consists of a supra-oesophageal ganglion, fused with the sub-oesophageal ganglion, a thoracic compound ganglion with distinct divisions into three pairs of ganglia, and a single abdominal ganglion.

The alimentary canal consists of an oesophagus; a large crop; a proventriculus, with a proventricular valve; a slightly convoluted mid-intestine; two pairs of Malphigian tubules; and a hind-intestine, with four rectal glands.

The pharyngeal structures reveal a powerful pumping apparatus.

A pair of salivary glands is situated in the prothorax and opens by a common duct, through the labium into the mouth.

Two pairs of thoracic and five pairs of abdominal spiracles are present. There is a pair of longitudinal tracheal trunks, which serve as a center of distribution for incoming air.

The circulatory system is made up of a five-chambered heart with four pairs of ostia; a slender aorta, which forms a thoracic ampulla and opens close to the brain.

The male reproductive organs consist of a pair of bilobed testes; a pair of short vasa deferentia; a pair of accessory glands; and a strongly muscular ejaculatory duct.

The female reproductive organs consist of a pair of ovaries, each ovary being divided into two closely allied ovarian tubes of the meroistic type, the arrangement of the nurse cells in the ova being peculiar to this type; a short muscular oviduct; and a strongly muscular, convoluted vagina. A single spermatheca and a pair of small colleterial glands open into the vagina.

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EXPLANATION OF PLATES.

Figs. 5, 7, 17—Schematic drawings.
Figs. 2, 3, 4, 8, 9, 12, 14—Half schematic drawings.
Figs. 6, 10, 11, 13, 15, 16, 18, 19, 20—Camera lucida drawings.
Figs. 21, 22—Outline of Reproductive Organs, schematic. Sections through parts indicated, camera lucida drawings.

PLATE I.

Fig. 1. Sensory hair.
Fig. 2. Muscle attachment to Body-wall.
Fig. 3. Muscle attachment to Endo-thorax.
Fig. 4. Section of Crop-wall.
Fig. 5. Longitudinal median section of *Braula coeca*.
Fig. 6. Malpighian Tubule.

PLATE II.

Fig. 7. Nervous System.
Fig. 8. Section of Mid-intestinal Wall.
Fig. 9. Section of Hind-intestinal Wall.
Fig. 10. Pulvillus.
Fig. 11. Salivary Gland.
Fig. 12. Abdominal Spiracle.
Fig. 13. Oenocytes.
Fig. 14. Meso-thoracic Spiracle.

PLATE III.

Fig. 15. Fat Bodies.
Fig. 16. Oenocytes in Fat Body.
Fig. 17. Dorsal Vessel.
Fig. 18. Cross-section of the heart.
Fig. 19. Nephrocytes.
Fig. 20. Trachea.

PLATE IV.

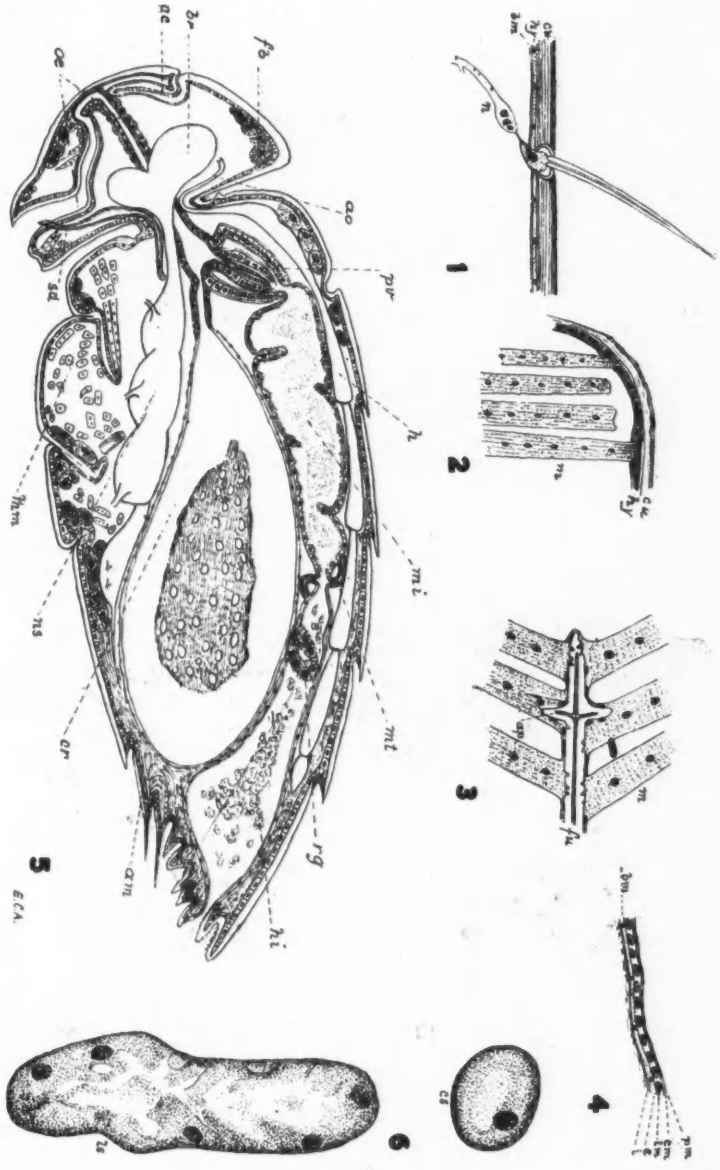
Fig. 21. Female Reproductive Organs.
Fig. 22. Male Reproductive Organs.

ABBREVIATIONS.

agl—accessory gland.
am—abdominal muscles.
ao—aorta.
ap—apodeme.
bm—basement membrane.
br—brain.
c—cuticula.
cc—ptilinum.
cm—circular muscle.
cs—cross section.
cr—crop.
cu—cuticula.
e—epithelium.
eccm—ectal circular muscle.
ed—ejaculatory duct.
encm—ental circular muscle.
fb—fat body.
fu—furca.
g abd—abdominal ganglion.
g fr—frontal ganglion.
g th—thoracic ganglion.
h, H—heart.
hi—hind-intestine.
hy—hypodermis.
i—intima.
lm—longitudinal muscle.
ls—longitudinal section.
m—muscle.
mg—mucous gland.
mi—mid-intestine.
mt—Malpighian tubule.
n—nerve.
ne—nephrocyte.
n ant—antennal nerve.
n lab—labial nerve.
n labr—labral nerve.
n max—maxillary nerve.
n opt—optic nerve.
ns—nervous system.
n—stomo-gastric nerve.
o—ostia.
oe—oenocyte.
oes—oesophagus.
ovd—oviduct.
ovt—ovarian tube.
p—penis.
pm—peritonial membrane.
pv—proventriculus.
rg—rectal gland.
sd—salivary duct.
sg—salivary gland.
sp—spermateca.
t—testis.
th—thoracic ampulla.
thm—thoracic muscles.
tr—trachea.
v—vagina.
vd—vasa deferentia.

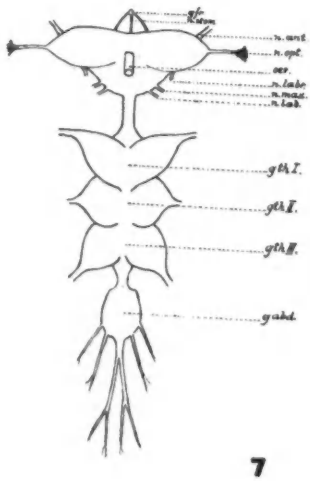
Braula Coeca Nitzsch
Alfonsus and Braun

PLATE I.



Braula Coeca Nitzsch
Alfonsus and Braun

PLATE II.



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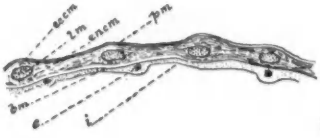

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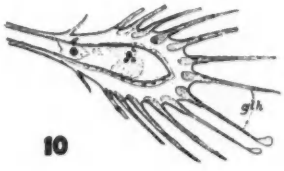

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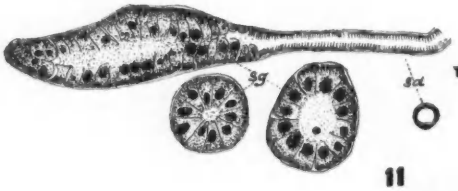

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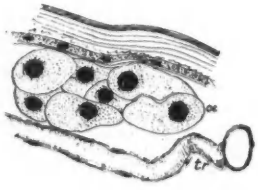

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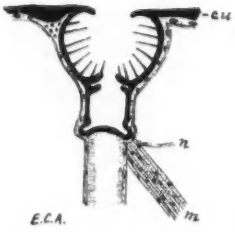

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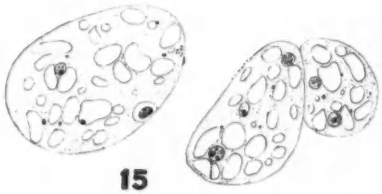
Braula Coeca Nitzsch
Alfonsus and Braun

PLATE III.



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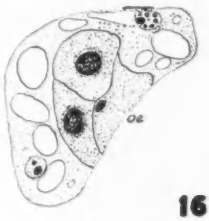

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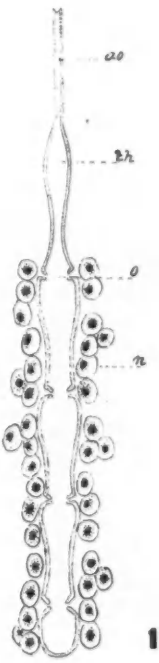

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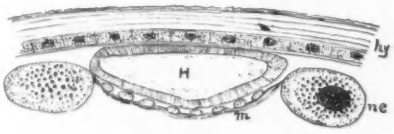

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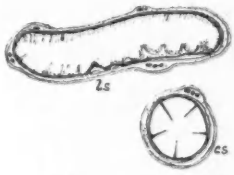

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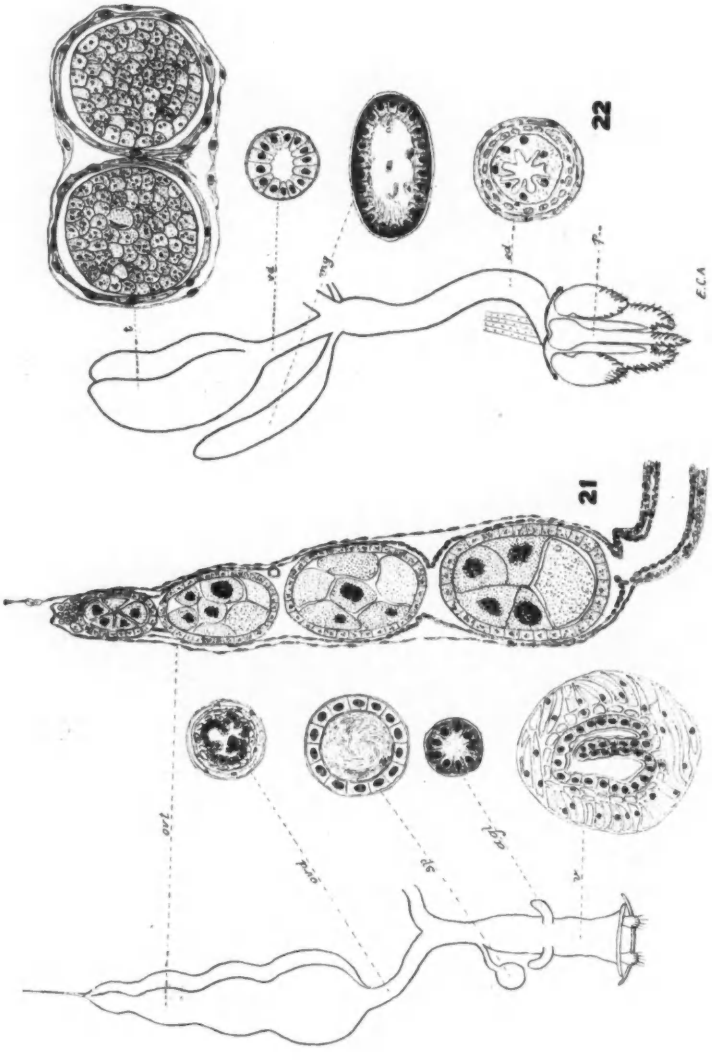
Braula Coeca Nitzsch
Alfonsus and Braun

PLATE IV.



TWO NEW MALLOPHAGA FROM TWO CLOSELY RELATED SHOREBIRDS.

HAROLD S. PETERS,
Bureau of Entomology, U. S. Department of Agriculture.

There are described herein two new species of Mallophaga collected from two species of shorebirds: Lesser yellowlegs, *Totanus flavipes* (Gmelin) and greater yellowlegs, *Totanus melanoleucus* (Gmelin), both common during migrations in the United States. These two sandpipers (Order Charadriiformes, Family Scolopacidæ) are almost indistinguishable in coloration but the greater yellowlegs is about one-third larger in size than the lesser yellowlegs. The two new species of Mallophaga are easily separated by the different male genitalia; in other characters they closely resemble each other; the larger louse is found on the larger bird.

Degeeriella falcigera, new species.

DESCRIPTION OF MALE.—*Head* of Philopterus type, rather elongate conical in shape, being one and three-fifths times as long as broad and twice as broad across the temples as at anterior border of clypeus. Clypeus with a slightly convex and expanded hyaline margin; signatural plate somewhat shield-shaped; distinct clypeal suture; trabeculæ distinct and uncolored, almost as long as first antennal segment, but not moveable. Antennæ with second segment longest, fifth longer than third or fourth, which are equal, pale with fifth segment darkest. Eyes clear, with a long and a short ocular seta. Three short lateral setæ on clypeus; two before trabeculæ; two long and two short setæ on rounded temples. Posterior edge of head slightly concave and bare. Color golden brown; with dark brown antennal bands interrupted at clypeal suture; temples margined with dark brown; mandibles, esophageal sclerite, narrow occipital bands, and triangular gular signature medium brown.

Thorax about two-thirds as long as head, golden brown with dark brown lateral margins. Prothorax trapezoidal, sides slightly diverging, with a short seta in latero-posterior angle. Pterothorax as wide as head and one and two-thirds times as long as prothorax, trapezoidal with diverging and slightly concave sides, and posterior edge slightly angled. A group of three pustulated setæ in latero-posterior rounded angle and two pustulated setæ nearer the middle on the posterior border. Legs all about equal in length, with femora rather robust, coxæ situated near lateral edges of thorax.

Abdomen of nine segments, elongate, golden brown with dark brown lateral margins, each segment with somewhat indistinct darker transverse markings, sutures lighter, segments 2 to 5 each having a narrow median uncolored line extending from the suture to middle of each segment. First segment short, slightly converging posteriorly; segments 2 to 6 about equal in length; fourth segment widest; segments 7, 8, and 9 rapidly narrowing posteriorly; segment 9 half the width of segment 6 and broadly rounded with about twelve small setæ projecting posteriorly. Pleurites long, pointed, projecting into preceding segment, and dark brown; the dark brown color extending toward the center in anterior half of segments, the spiracles on segments 2 to 7 in lateral light brown area just posterior to middle of segment. On dorsal surface segment 1 has two setæ on posterior border; segment 2 has four setæ; segments 3 to 5 have six setæ. Some setæ in lateral angles and on ventral surface. Genitalia very distinctive. Basal plate consisting of two rods extending to the fifth abdominal segment. Parameres long, curved, and pointed; endomeres with peculiar sharp lateral projection and divided into a dorsal and a ventral projection at their anterior end. (Fig. 1).

DESCRIPTION OF FEMALE.—The same as the male except that it is somewhat broader and longer; the ninth abdominal segment is bilobed; and the eighth segment has a number of setæ on the lateral and posterior margins.

AVERAGE MEASUREMENTS IN MILLIMETERS.

	MALE		FEMALE	
	Length	Width	Length	Width
Head	0.404	0.253	0.423	0.267
Prothorax	.106	.188	.110	.195
Pterothorax	.174	.257	.195	.268
Abdomen	1.000	.363	1.146	.392
Total	1.684		1.874	

Type Host: Lesser yellowlegs, *Totanus flavipes* (Gmelin).

Type locality: Sandusky, Ohio.

Type (*holotype and allotype*): Cat. No. 43514 U. S. N. M.

The holotype male and allotype female were collected from the type host at the type locality on September 12, 1925, by myself. The paratypes are in the collection of the Bureau of Entomology and in my personal collection.

Described from seventy specimens all collected from lesser yellowlegs as follows: Two males and three females from Washington D. C., September 24, 1919, by E. A. Chapin

(in National Museum collection); four males and three females from Columbus, Ohio, May 6, 1925, by myself; four males and six females from North Eastham, Mass., September 10, 1925, by O. L. Austin, Jr.; eleven males and fifteen females from Sandusky, Ohio, September 12, 1925, by myself; one female from Sandusky, Ohio, October 14, 1925, by M. B. Trautman; one female from Columbus, Ohio, April 13, 1926, by R. W. Franks; one female from Columbus, Ohio, April 30,

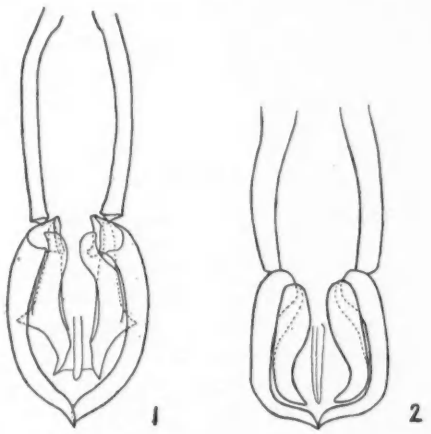


Fig. 1. *D. falcigera* n. sp., male genitalia, ×200.
Fig. 2. *D. austini* n. sp., male genitalia, ×200.

1926, by myself; one male and one female from Chincoteague, Virginia, March 26, 1927, by myself; one male and three females from Munuscong Bay, Michigan, August 19, 1927, by C. F. Walker; and eight males and five females from South Caicos Island, Bahama Islands, July 29, 1930, by myself (Bish. No. 15186). Dr. E. A. Chapin, of the National Museum, suggested the name *falcigera* for this species.

Degeeriella austini, new species.

DESCRIPTION OF MALE.—Broader and longer than *D. falcigera*, with latero-posterior angles of pterothorax having two long and three shorter setæ, and three setæ nearer the middle along the posterior border; the pleurites more narrow. Genitalia distinctive. The two rods of the basal plate are shorter than those of *D. falcigera*, extending

into the sixth abdominal segment; the parameres and endomeres are sharply elbowed and pointed; the endomeres are folded at their anterior end. (Fig. 2).

DESCRIPTION OF FEMALE.—Almost identical with the female of *D. falcigera*, but somewhat broader and longer.

AVERAGE MEASUREMENTS IN MILLIMETERS.

	MALE		FEMALE	
	Length	Width	Length	Width
Head	0.493	0.316	0.501	0.321
Prothorax	.126	.240	.124	.240
Pterothorax	.210	.320	.217	.319
Abdomen	1.118	.468	1.250	.479
Total	1.947		2.092	

Type host: Greater yellowlegs, *Totanus melanoleucus* (Gmelin).

Type locality: Windy Tickle, Labrador.

Type (holotype and allotype): Cat. No. 43515 U. S. N. M.

The holotype male and allotype female were collected from the type host at the type locality on August 23, 1926, by O. L. Austin, Jr. The paratypes are in the collection of the Bureau of Entomology and in my personal collection.

Described from nine specimens, all collected from greater yellowlegs by O. L. Austin, Jr., as follows: Three females from North Eastham, Mass., September 14, 1925; and five males and one female from Windy Tickle, Labrador, August 23, 1926. Named in honor of Dr. O. L. Austin, Jr., who has sent the writer many interesting Mallophaga from birds he has collected.

D. falcigera and *D. austini* are not very close to any described species of Mallophaga. *D. boephila* (Kellogg), described from a killdeer, *Oxyechus vociferus* (Linn.), is somewhat similar but is much narrower and easily distinguished by the markings and genitalia.

THE GENUS DRYLIX IN NORTH AMERICA, (HOMOPTERA, CICADELLIDÆ).*

PAUL B. LAWSON,
Lawrence, Kansas.

In his study of the North American Species of Euscelis and Allied Genera, Sleesman records five species in the genus Drylix, one species of which, *D. truncatus*, he described from male specimens. The writer had before him, awaiting description when this paper appeared, both males and females of this species and specimens of two additional species in the genus. In this paper the allotype of *D. truncatus* and these two additional species are described, and the key to the genus modified to contain the seven species now found in the genus in North America.

KEY TO SPECIES OF DRYLIX.

1. Vertex slightly but definitely produced..... 2
   Vertex not definitely produced, nearly parallel margined..... 3
2. Species usually under 5 mm.; male plates moderately long....*striolus* Fall
   Species usually over 5 mm.; male plates very long.....*utahnus* n. sp.
3. Male plates not caliper like..... 4
   Male plates caliper like..... 6
4. Male plates truncate apically.....*truncatus* Sleesman
   Male plates rounded apically..... 5
5. Male plates shorter than valve.....*medianus* n. sp.
   Male plates longer than valve.....*parallelus* (Van Duzee)
6. Male plates long, apices narrowly produced..*divaricatus* Sanders and DeLong
   Male plates short, apices bluntly produced.....*uneolus* Ball

Drylix truncatus Sleesman.

(Figs. 3, 3a, 3b.)

The male only of this species was described by Sleesman. Following is the description of the female.

Allied to *parallelus* but broader and darker and with distinct genitalia. Length 5.5 mm.

Head distinctly wider than pronotum; vertex parallel margined, three times as wide as long. Pronotum about twice as long as vertex, nearly three times as wide as long. Elytra greatly exceeding abdomen.

Color: Well colored specimens strikingly black and yellow. Vertex mostly black, with narrow yellow line between ocelli and wider yellow band on posterior margin. Pronotum with anterior margin narrowly

*Contribution from the Department of Entomology, University of Kansas.

black and with broad black band on posterior half entirely surrounded by yellow. Scutellum yellow, disc and basal angles brokenly black. Elytra smoky to black, nervures mostly yellow. Face mostly black; arcs and median line on front, sides of clypeus, spots on loræ and margins of genæ, yellow. Legs mostly black, marked with yellow. Underside mostly black.

Genitalia: Female last ventral segment about as long as preceding, median third of posterior margin shallowly concave, outer thirds still more shallowly concave and separated from middle third by a sharp and distinct point.

A specimen from Atherton, Mo., taken by C. F. Adams on June 11, 1922, is designated as the *Allotype* of this species and is deposited in the Snow Entomological Collection. Other specimens are at hand from Cherokee and Douglas counties, Kansas; Atherton, Mo.; and Arlington, N. J.

Drylix medianus n. sp.
(Figs. 2, 2a, 2b.)

Allied to *parallelus* but more slender and elongate and with male plates shorter. Length 5.25–5.5 mm.

Head distinctly wider than prothorax; vertex very slightly longer at the middle than next the eye, three times as wide as long. Pronotum about twice as long as vertex, a little over twice as wide as long, anterior margin rather strongly convex. Elytra greatly exceeding abdomen.

Color: Well colored specimens dark brown and yellow. Vertex with narrow yellow line between light ocelli, posterior margin rather broadly yellow, the rest black. Pronotum mostly yellow, anterior margin narrowly dark brown and most of disc brokenly dark brown. Scutellum yellow, basal angles and portion of disc dark. Elytra mostly smoky to dark brown, nervures light yellow. Front black except for yellow arcs; sutures of loræ and clypeus and middle line of latter, dark; rest of face yellow. Legs yellow, marked with brown. Underside mostly dark, margins of segments, plates, and pygofer light.

Genitalia: Female last ventral segment half longer than preceding; posterior margin with rounded median notch extending about one-third of distance to base and with distinct obtuse angles on either side of notch. Male valve large, bluntly angled; plates slightly shorter than valve, margins broadly convex, rather spiny.

Holotype, male, Grand Marais, Minn., Aug. 11, 1922, taken by H. H. Knight. *Allotype*, female, and a male and female *paratype*, same data.

Holotype and female paratype deposited in Snow Entomological Collection. Allotype and male paratype in Dr. Knight's collection.

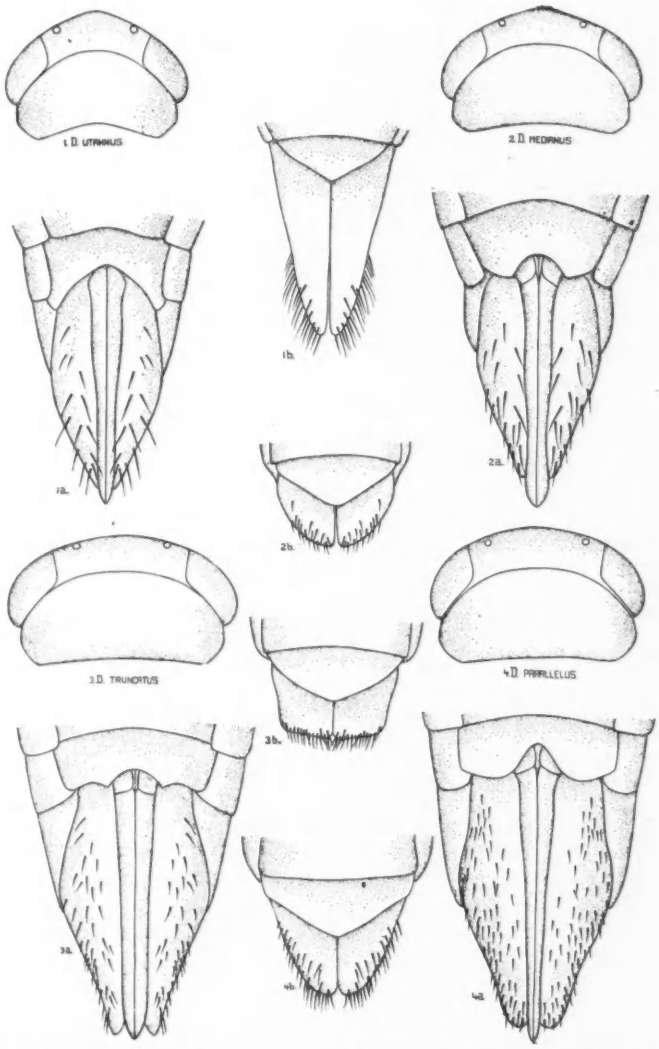


Fig. 1. *Drylix utahnus* n. sp.
Fig. 1a. *Drylix utahnus*, female genitalia.
Fig. 1b. *Drylix utahnus*, male genitalia.
Fig. 2. *Drylix medianus* n. sp.
Fig. 2a. *Drylix medianus*, female genitalia.
Fig. 2b. *Drylix medianus*, male genitalia.
Fig. 3. *Drylix truncatus* Sleesman.
Fig. 3a. *Drylix truncatus*, female genitalia.
Fig. 3b. *Drylix truncatus*, male genitalia.
Fig. 4. *Drylix parallelus* (Van Duzee).
Fig. 4a. *Drylix parallelus*, female genitalia.
Fig. 4b. *Drylix parallelus*, male genitalia.

This species has male genitalia midway between *truncatus* and *parallelus*. The plates are shorter than in the latter but not truncate as in the former. The female segment has a shallower notch than in *parallelus* and the outer thirds of the posterior margin are not concave as in *truncatus*. The genitalia of all three species are figured for comparison. In general appearance also this species is more slender than the other two to which it is closely related.

The writer is indebted to Dr. H. H. Knight for all four specimens available.

Drylix utahnus n. sp.
(Figs. 1, 1a, 1b.)

Closely allied to *striolus* but larger and with male plates much longer. Length 5–5.5 mm.

Vertex but slightly produced at the middle, slightly over twice as wide as long. Pronotum about twice as long as vertex, anterior margin strongly convex. Elytra very long, greatly exceeding abdomen.

Color: General color dirty or brownish yellow. Vertex yellow with definite black band caudad of ocelli separating yellow basal portion from narrow yellow line between ocelli. Pronotum dirty yellow with signs of brownish mottling on anterior third. Scutellum entirely yellow or with few brown spots. Elytra smoky yellow, nervures paler, cells smoky to brown. Face yellow with arcs of front and sutures black. Legs yellow, marked with brown. Underside varyingly black and yellow.

Genitalia: Female last ventral segment half longer than preceding, posterior margin broadly concave about half way to base. Male valve small, triangular; plates triangular and very long, their acute apices greatly exceeding pygofer.

Holotype, female, Richfield, Utah, July 15, 1929. Light trap. Deposited in United States National Museum.

Allotype, male, same data. Deposited in Snow Entomological Collection.

Both specimens were made available for study through the courtesy of Mr. E. W. Davis.

SEVEN NEW SOUTHERN SPECIES OF THE MAYFLY GENUS HEXAGENIA, WITH NOTES ON THE GENUS.*

JAY R. TRAVER.

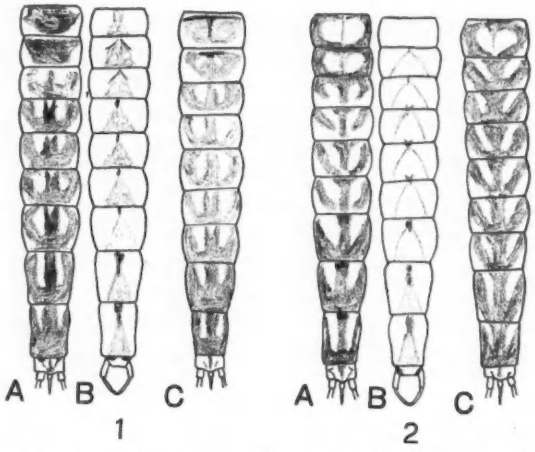
From material in the collection at Cornell University, and from other material collected by Prof. J. G. Needham from West Virginia, and by Miss L. E. Brett and the author from North Carolina, seven new southern species of the genus Hexagenia are herein described. An attempt has been made to formulate keys to the known species of Hexagenia in the United States and Canada, for both males and females (in so far as the latter are known). Likewise a tabulation of some of the characters of the males of each species has been prepared, in the hope that this table may supplement the key, and aid in identification. Color patterns of both males and females of the new species are given, to supplement those of several previously described species published by other authors. Notes on several species of Hexagenia nymphs are likewise presented.

In descriptions of the wings of the various species, the term "costal margin" is used to include both the costal and subcostal cells. Where reference is made to dark spots in the wing, such spots are formed, as in the species *H. bilineata*, by some of the cross veins being margined or bordered on each side with black or very dark purple.

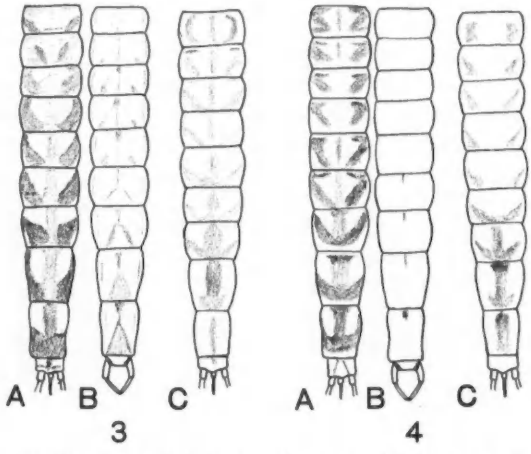
COLOR PATTERNS.

Typical color patterns of the abdomens of the males of several species of the genus Hexagenia have been figured by previous writers. Thus Ulmer, 1921, (p. 237, Figs. 6 and 7) has figured *H. bilineata* and *H. limbata;* and McDunnough, 1927, (p. 117, Fig. 1) has shown *H. bilineata*, *H. atrocaudata*, *H. rigida*, *H. affiliata*, and *H. viridescens*. In the present article are given typical patterns for the seven new species herein described. The first figure of each group represents the dorsal aspect of the male abdomen; the second, the ventral aspect of the same; the third (not known for *H. rosacea*) shows the dorsal aspect of the abdomen of the female. (See text Figures 1–7.)

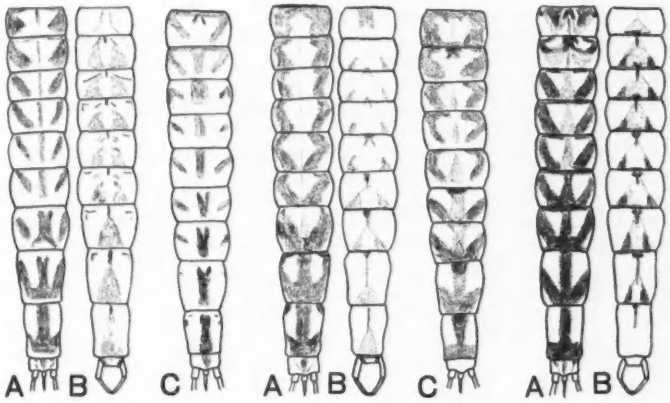
*Contributions from the Limnological Laboratory of Cornell University.



1. *Hexagenia mingo.* A and B, dorsal and ventral abdominal markings of male; C, dorsal of female.
2. *Hexagenia orlando.* A and B, dorsal and ventral abdominal markings of male; C, dorsal of female.



3. *Hexagenia elegans.* A and B, dorsal and ventral abdominal markings of male; C, dorsal of female.
4. *Hexagenia carolina.* A and B, dorsal and ventral abdominal markings of male; C, dorsal of female.



5 6 7

5. *Hexagenia weewa*. A and B, dorsal and ventral abdominal markings of male; C, dorsal of female.
6. *Hexagenia marilandica*. A and B, dorsal and ventral abdominal markings of male; C, dorsal of female.
7. *Hexagenia rosacea*. A and B, dorsal and ventral abdominal markings of male.

TYPES OF GENITALIA.

In the tabulation of characters of Hexagenia males, it will be noted that the types of genitalia are indicated by Roman numerals I to VI, inclusive. These are listed in the order in which they have been described and figured. A brief résumé of these types follows.

I. *Limbata type*. First figured by Eaton, 1883–88 (Pl. VII, Fig. 11c); next by Needham, 1920, (Pl. LXXXI, Fig. 63), under the name *bilineata*, form *variablis;* and most recently by Ulmer, 1921 (p. 236, Fig. 4). The penes are hook-like and bent forwards, in characteristic position approaching or even overlapping one another at the tips. Ulmer indicates (p. 238) that the end-joints of the forceps limbs in this form are broad. This statement does not hold good, however, for all the species examined by the writer which have the *limbata* type of genitalia. Thus, *H. venusta* has typical *limbata* type penes, but the end-joints of the forceps limbs are as slender as in typical *H. bilineata*. This type of genitalia is found in a number of species, (Fig. 19).

II. *Bilineata type*. Figured by Needham, 1920 (Pl. LXXXI, Fig. 62) as *bilineata*, form *falcata;* and by Ulmer, 1921 (p. 236, Fig. 5) In this form the penes are elongated at the tip into bill-like structures which often overlap, as the penes characteristically approach and touch one another. This form of genitalia seems confined to the one

species *H. bilineata* Say. The end-joints of the forceps limbs, as indicated by Ulmer, are characteristically thin and slender, (Fig. 14).

III. *Recurvata type.* Figured by Morgan, 1913 (p. 395, Fig. 3). The penes are recurved at the tip, and do not approach one another. The first joint of the forceps limb is remarkably short and stout, the second unusually long, the two end joints rather short and stout. This type seems confined to the single species *H. recurvata* Morgan, (Fig. 18).

IV. *Rigida type.* First figured by Eaton, 1883–88, (Pl. VII, Fig. 11b 2) as *bilineata;* by Needham, 1920 (Pl. LXXXI, Figs. 61 and 65) as *bilineata* and *falcata;* later figured and named by McDunnough, 1924 (Pl. I, Fig. 3). The penes here are long and straight, not approaching one another. The forceps limbs are stout, as are also the end-joints. This type may be confined to the species *H. rigida* McD., although several specimens in the Cornell University collection, which do not exhibit characteristic markings of this species, do possess the *rigida* type of genitalia. (Fig. 16).

V. *Atrocaudata type.* Figured by Needham, 1920 (Pl. LXXXI, Fig. 64) as *bilineata*, form *munda;* and figured and named by McDunnough, 1924 (Pl. I, Fig. 2). The penes are short and broad, bluntly pointed, and do not approach one another closely. The forceps limbs are quite thick-set; the end-joints, especially the third joint (first of the end-joints) are unusually long and stout. This type seems confined to the single species *H. atrocaudata* McD. (Fig. 12).

VI. *Carolina type.* This type somewhat resembles the *limbata* type. In a few cases the two seem to intergrade, so that it is difficult, as in the case of the new species *H. marilandica*, to state which type is present. In the typical form, however, as shown well by the other new species here described, the penes are but slightly bent, not showing the characteristic hook of *limbata*, and either stand erect, bend slightly outward, or rarely approach one another slightly. The tips always bend inward, not outward. The forceps limbs may be stout, with very long second joint, and the third joint also unusually long and stout, as in *H. weewa*, and to a lesser degree in *H. carolina*. Or they may be more slender, and the end-joints be unusually short, as in *H. elegans*. Several of the southern species show this type of genitalia. (Figs. 10, 11, 13, 17, 20, 22).

Hexagenia elegans, n. sp.

A very small species, Hind wings of male bordered with purplish brown, markings of abdomen predominantly purplish red.

	Measurements.			
	Body	*Tails*	*Foreleg*	*Fore-wing*
Male subimago (3 specimens)	13½–15	14–17	5	11–12
Female subimago (2 specimens)	16 –17	12–12½	5–6	12–14
Male imago (20 specimens)	12 –17	30–38	8–10	10½–12
Female imago (20 specimens)	14 –19	18–27	5–7	12–18

MALE IMAGO.

Head: Upper portion of compound eye golden tan. Vertex cream-colored, occiput flesh-colored. Ocelli ringed at base with black, above this with purplish rose. Dorsal aspect of frontal carina purplish. Second antennal joint and base of filament light rose. Diameter of eye is to space between the eyes approximately as 1:1.

Thorax: Prothorax flesh-colored, with two longitudinal dorsal mahogany-red stripes. Meso- and metanotum and portion of pleurum of metathorax creamy white. Mesopleurum light red-brown. Prosternum white with dark purple spot posteriorly. Anterior of mesosternum and all of metasternum dark mahogany-red. Posterior of mesosternmum lighter shade of same.

Legs: Femur and tibia of foreleg dark rose-red; tarsus purplish-brown except proximal half of second, third and fourth joints, which are white. Other legs white. Claws, distal joint of tarsus except at base, distal border at fourth tarsal joint, and faint border at other tarsal joinings, purplish brown.

Wings: Very iridescent. Fore wing with dark brown costal border, to vein R. Outer margin of hind wing purplish-brown. Main longitudinal veins of fore wing, of costal area of hind wing, and cross veins of both wings, purplish black. In both wings, prominent purplish-black spots.

Abdomen: Ground color white, faintly flushed with pink ventrally on segments 1–6; definitely yellowish on 7–10. Dorsal markings consist of reddish-brown longitudinal median stripe on 7–10, continued forward as a faint grey line on 1–6, very narrow on 1–3. On each side of tergites 1–9, a rose-brown oblique mark, its base on or near the posterior margin, extends laterally to the pleural fold. On tergites 1–4 it has the shape of a parallelogram, on 5–9 wedge-shaped. This mark varies in color on different specimens from rose or red-brown to greyed lavender. Tergite 10 with brown oblique lateral marks. Sternite 9 with a rose-colored triangle, its base on the posterior margin, its apex not attaining the anterior margin. Other sternites with rose lateral stripes from posterior border half-way to pleural fold, extending obliquely forward toward mid-ventral line. In light-colored specimens these stripes do not attain the median line; in darker specimens, they reach it near the anterior border.

Genitalia: Very slender, of the *carolina* type. Basal joint of forceps limb, distal one-third on the second joint, and its ventral ridge, purplish brown (in light specimens, grey). The two short distal joints, which are remarkably small, light brown to yellowish. Forceps base purplish brown, a rose spot on each side. Penes with ventral purplish brown stripe. (Fig. 11).

Tails: Distal portion of each joint dark brown, with darker ring at joining. Proximal portion of each greyish white. In some joints the dark brown occupies all but a narrow white proximal ring.

FEMALE IMAGO.

Entire body creamy white. Ocelli ringed with black, rose spot on each side at base. Grey-purple stripe on pronotum, becoming golden yellow on mesonotum. Yellowish brown oblique mark along main lateral suture of mesopleurum, to base of middle leg.

Legs: Foreleg with rose band at base of femur and near distal end of tibia. Claws, distal two-thirds of last tarsal joint, and all joinings except base of femur, purple-brown. Other legs with claws and last tarsal joints similar, but no color at joinings save those of the third and fourth tarsal segments.

Wings tinged with greenish yellow; longitudinal veins yellow, cross veins purple black. Neither wing with brown or purple margin.

Abdomen: Dorsally with longitudinal dark-grey median stripe, as in male. Tergites 1 and 2, in some specimens, with large central grey-black patch; 1 margined posteriorly with black. Grey-brown arms extend forward for a short distance from each side of median brown band, at posterior margin.

Tails: Yellowish white, ringed indistinctly with grey at joinings. In proximal portion, every third or fourth joining with blackish-purple ring.

Holotype: ♂, imago. Taken from the Chowan River, near Winton, Hertford Co., N. C. by Miss L. E. Brett. Second week of August, 1930. No. 917.1 in C. U. collection.

Allotype: ♀, imago. Same. No. 917.2 in C. U. collection.

Paratypes: 12 ♂s and 8 ♀s, all imagos. Same place and collector. Second and third weeks of August, 1930. No. 917.3–.22, in C. U. collection.

Miss L. E. Brett gives the following account of the collecting of *Hexagenia elegans*.

"These Hexagenias were captured in northeastern North Carolina at Tuscarora Beach, on the Chowan River, about three miles east of the little town of Winton and eight miles from the point where the Meherrin and the Nottaway Rivers unite to form the Chowan. This location is approximately seventy miles from the sea.

At the point where the Hexagenias were caught the river is something like 35 to 40 feet deep and 500 feet or more in width. On the west bank is a wide sandy beach and on the east a swamp extending a mile out from the river.

The Hexagenias were seen in great numbers between eight and ten o'clock in the evening during the latter part of July and most of August. The writer first saw them sitting on the electric light wires over the bathing beach. Upon investigation they were discovered on the window of the merry-go-round ticket office and even swarming on the canvas at the top of the merry-go-round, which was some 150 yards from the water. They took possession of the dance pavilion and became a nuisance at the soda shop. Some were even found

sitting on passersby at the beach. They literally took the place 'by storm.' The adults were seen as early as 7:30 o'clock dipping in the shallow waters.

When this discovery was made, cages were secured and the mayflies were picked by hand from every object in sight, put in the cages and left to finish transformation. Many of them did transform, while others died in the process. Then a search for the nymphs was made. But though the sandy silt was dug up out as far as a person could wade, no trace of a single nymph could be found."

Hexagenia mingo, n. sp.

A medium-sized species. Hind wing of male with or without purplish outer margin. Dorsal aspect of abdomen with reddish brown markings.

MEASUREMENTS.

	Body	*Tails*	*Foreleg*	*Fore-wing*
Male subimago..... (1 specimen)	17½	19	5	15
Female subimago..... (1 specimen)	25	?	6	20
Male imago..... (2 specimens)	17½	32–36	12	14½
Female imago..... (1 specimen)	23	29	9	21

MALE IMAGO.

Head: Light tan. Vertex with cream yellow markings. Black ring at base of ocelli, and space between them black. Dorsal aspect of median carina dark grey. Occiput with purplish red marks. Upper part of compound eye cream to light tan. Second antennal joint and filament brown. Compound eye is to space between eyes approximately as 1 : 0.75.

Thorax: Pronotum light tan, with rather wide dark reddish brown stripes, extending to wing bases. Mesonotum light tan with dark brown markings. Anterior of mesopleurum and metanotum light brown. Other pleura cream-white. Anterior third of prosternum cream-white, other parts very dark reddish brown. Mesosternum light red brown in center, bordered by dark brown. Metasternum dark brown.

Legs: Coxa and trochanter of foreleg brown. Femur and tibia mahogany red-brown, darker at joinings. Tarsus dull yellowish brown, darker at joinings and with darker streaks. Other legs canary yellow. Claws, fifth tarsal joint and joinings of all but first tarsal joint purplish brown.

Wings: Costal margin of fore wing reddish brown except at apex and next to vein C in basal portion, which regions are light tan. Longitudinal and cross veins of both wings dark purplish. Several cross veins in each wing margined with purple. Hind wing with definite purplish-brown outer margin in some specimens, but lacking in others.

Abdomen: Cream white or faintly pinkish ground color, yellow on 8–10. Rather wide median longitudinal stripe on dorsum, dark reddish brown; wider at posterior margin of each tergite. On 3–9, wide reddish brown bands arise from median stripe at posterior margin, extend outward to pleural fold just below the anterior margin, then upward and inward to meet the anterior margin a short distance from median stripe. Each side of each tergite is thus largely reddish brown, the ground color showing slightly at anterior lateral angle, in a large triangle at posterior lateral angle, and a triangular to round spot on each side of center, enclosed except anteriorly near median line. Tergite 10 yellow with greyish brown stripe, and two lateral stripes ending in dark spots near anterior lateral angle. Ventrally, light reddish brown triangles, their bases on the posterior margin, extend forward to the anterior margin on sternites 1–8. Wider basally on 1–6, narrow on 7 and 8. Each triangle becomes darker in color over ganglionic area, and on posterior sternites a dark mark extends on median line almost the length of the segment. In center of each sternite near median line, a clear round spot. Sternites 9 and 10 yellow, with reddish median line, no lateral marks.

Tails: Rudimentary median tail with dark band at each joining, dorsally. Joints of outer tails light yellow-brown in basal half, darker brown distally, joinings still darker. Near distal end of seta, joints brown except for yellow proximal ring.

Genitalia: Almost intermediate between *carolina* and *limbata* types, but considered here as of the *limbata* type. Forceps base yellow with two purplish brown spots at anterior margin, opposite forceps limbs. Forceps limbs yellow; basal joint streaked ventrally with purplish brown. Distal end of second joint and the short end joints same color. Penes with purplish brown streak on distal half, ventrally. (Fig. 21).

FEMALE IMAGO.

General color of body creamy yellow. *Head* bright sulphur yellow. Vertex cream-colored with two broad purplish-black oblique lateral bands from posterior outer margin toward center. Median carina, bases of ocelli and space between them, black. Antenna as in male.

Thorax: Pronotum greyish white with purplish grey longitudinal stripes. Mesonotum cream, with faint greyish marks near center, a purplish brown median mark on posterior half, its posterior extension same color. Metanotum cream with purplish markings. Pleura cream marked with light brown. Thoracic sternites cream; posterior of prosternum, anterior of mesosternum, and coxæ of middle legs marked with purplish brown.

Legs: Creamy white. On foreleg trochanter and dorsal aspect of femur streaked with rose. Joinings of femur, tibia and tarsus, as well as claw and most of fifth tarsal joint, dark purplish. Lavender mark near distal end of tibia. On other legs, claw and fifth tarsal joint, likewise joinings of last three tarsal joints, greyed lavender.

Wings: Costal border of fore wing yellowish. Vein C amber; other longitudinal veins in upper part of fore wing purplish brown. Cross veins purple-black.

Abdomen: Color pattern arranged very much as in male, but the anterior extensions of the lateral bands not approaching the median line. Thus a greater amount of ground color is visible between these lateral arms and the median longitudinal stripe. Median stripe dark greyish brown; on tergites 3–7, bifid anteriorly. Lateral marks same general color. Eggs within body give pink tinge to all anterior segments, before their deposition. Tergite 10 yellow. Ventrally, ganglionic areas white. A short purplish streak on median line at anterior of sternite 9 and indistinct purplish lateral marks on 10. Sternites 9 and 10 definitely yellow. No other ventral marks.

Tails: Creamy white, purplish black at joinings.

Holotype: ♂. Reared from nymph taken at Millwood, W. Va., by Prof. J. G. Needham. June 25, 1930. No. 920.1 in Cornell Univ. collection.

Allotype: ♀. Same as above. No. 920.2, in Cornell University collection.

Paratypes: ♂ imago, and ♂ and ♀ subimagoes. Same. No. 920.3–.7, in Cornell collection.

Hexagenia marilandica, n. sp.

A rather large species, superficially similar to *H. rosacea*, but anterior abdominal tergites lacking median stripe. Second tarsal joint of foreleg of male proportionately longer, and compound eye somewhat smaller.

MEASUREMENTS.

	Body	*Tails*	*Foreleg*	*Fore-wing*
Male imago (1 specimen)	18	48	12	16
Female imago (1 specimen)	27	36	8	25

MALE IMAGO.

Head: Greyish white. Vertex cream-colored. Upper half of compound eyes slate grey. Ocelli with broad black basal ring, above this a narrower lavender ring. Dorsal aspect of median carina purplish black. Second antennal joint purplish, filament light brown. Compound eye is to space between eyes approximately as 1:1.

Thorax: Pronotum with yellowish tinge, the purplish brown longitudinal stripes rather broad and extending to wing base. Mesonotum and pleura creamy white, the former bordered and the latter marked with light brown. Metanotum creamy yellow with lavender markings. Prosternum white, two purple streaks between the legs. Mesosternum dark purplish rose anteriorly, its posterior portion light tan with lavender to rose marks on each side. Metasternum white, bordered laterally and posteriorly with purplish. Antecoxal pieces light tan flushed with rose.

Legs: Coxa and trochanter of foreleg purplish. Femur and tibia rose-red, darker at joinings. First tarsal joint, distal one-third of second to fourth joints, and all of the fifth joint with claws, purplish brown. Other legs creamy white. Coxa of second leg purplish red anteriorly. Claws, distal two-thirds of fifth tarsal joint, and joining of fourth and fifth, purplish brown.

Wings: Costal border of fore wing brown, darker in distal half but lighter again at apex. Longitudinal veins of fore wing brownish rose, cross veins purplish black in both wings. Several cross veins in each wing bordered with purplish black. No dark outer border on hind wing.

Abdomen: Ground color creamy white, flushed faintly with pink on dorsum; yellowish on 8–10. Greyish rose median longitudinal stripe on 6–10; indicated only as very faint grey line on 1–6. Tergite 1 purplish brown next to pleural fold and on anterior margin. Lateral oblique bands on 2–7 running from broad base on posterior margin on each side, laterally to pleural fold near anterior lateral angle. An upward and inward extension of each seems to join the base of the similar mark in the tergite directly anterior. Thus a zigzag pattern is formed along each side. On tergite 8 the lateral stripe is broader at base, more definitely rose-colored, and does not so clearly join the stripe of the anterior tergite. Tergite 9, this band is merely an extension laterally from the posterior border of the median stripe, and does not reach to the middle of the pleural fold. A small rose spot in anterior lateral angle. Tergite 10 yellow, a faint rose median stripe and two definite oblique lateral brown ones. Ventrally, the ganglionic area on each sternite indicated by a purplish mark, which on 7–9 extends more than half the length of the segment. On sternites 2–6, an oblique grey-rose mark arises from posterior border between median line and pleural fold, and extends forwards and inwards to about the middle of each side of each sternite. On 7–9, these marks are broader posteriorly and reach median line near center of sternite.

Tails: Near base, proximal half of each joint yellow, distal half dark reddish brown. In remainder of tail, each joint dark reddish brown, darker distally, except for yellow proximal ring.

Genitalia: Of the *carolina* type. Forceps base amber; penes and forceps same color. Basal and second joint of forceps limbs purplish brown. Penes with dark purplish brown longitudinal stripe. (Fig. 22).

Female Imago.

Head: Creamy white. Median carina in dorsal aspect black distally, two dark streaks on each side near base. Ocelli ringed with black at base. Filament of antenna amber.

Thorax: Pronotum greyish white with broad purplish brown longitudinal stripes Meso- and metanotum light tan with brown and amber markings. Pleura creamy white, with wide lateral suture to base of middle legs brown and amber; other sutures brown. Pro- and metasternum creamy white. Mesonotum yellowish tan with brown borders. Antecoxal pieces brownish lavender.

Legs: Foreleg, femur and tibia amber brown, greyish at joinings. Tarsus greyish yellow; fifth tarsal joint, claws and joinings greyed lavender. Other legs yellowish white. Claws, all but base of fifth tarsal joint, and narrow line at tarsal joinings, light greyed lavender.

Wings: Costal border of fore wing greyish yellow. Longitudinal veins in upper part of fore wing, and vein Sc of hind wing amber to light brown. Other longitudinal veins greyish. Cross veins of both wings purplish black.

Abdomen: Pale yellow dorsally, creamy white ventrally. Tergites 1 and 2 purplish grey on each side and on anterior border. Also with two short oblique grey bars from middle anterior border extending laterally from grey median line. Posterior lateral angle of 2 creamy white. 3–6 with grey triangle on median line, wider posteriorly. On 7–9, this median stripe is brownish grey, widened both posteriorly and anteriorly, darker at anterior border. Lateral oblique purple-brown marks on tergites 3–6 arising near anterior lateral angle, with wide arm extending downwards and inwards almost to posterior border at median line. Narrower arm extends parallel to anterior border, almost to median line. On 7–9 this mark arises from posterior border as wide extension of median line, and runs laterally almost to pleural fold, not extending above center of tergite. On these tergites also the marks become darker. Tergite 10 with narrow median stripe. Ventrally, a purplish black streak usually appears at each ganglionic area. No other ventral markings.

Tails: Yellowish, ringed with purplish black at each joining.

Holotype: ♂, imago. Taken at Conococheague Park, Washington Co., Md., June 3, 1925. Collected by Mr. Virgil Argo. No. 921.1, in C. U. collection.

Allotype: ♀, imago. Same. No. 921.2, in C. U. collection.

Paratype: ♀, imago. Same. This specimen lacks the purplish mark on ganglionic area, but otherwise corresponds with the female allotype. No. 921.3, in C. U. collection.

Hexagenia carolina, n. sp.

A large species, predominantly yellowish white, male with greyed rose to lavender markings. No dark outer border on hind wing.

	Measurements.			
	Body	*Tails*	*Foreleg*	*Fore-wing*
Male subimago..... (2 specimens)	20–24	21–27	7– 8	15–16
Female subimago..... (5 specimens)	27–35	18–32	8– 9	22–25
Male imago..... (5 specimens)	20½–24	41–43	9–12	14½–17
Female imago..... (14 specimens)	25–32	35–45	10½–12	23–27

MALE IMAGO.

Head: Creamy white. Upper part of compound eye golden brown. Cream-yellow markings on vertex. Ocelli with black ring at base; one purplish spot near base of compound eye, another near median carina. Dorsal aspect of median carina purplish. Compound eye is to intervening space between eyes approximately as 1:1.

Thorax: Pronotum creamy white, with two longitudinal purplish streaks. Meso- and metanotum yellowish with light brown markings. Brown lateral streak on mesopleurum, to base of middle leg. Ventrally, coxæ of middle legs and median anterior portion of mesosternum purplish, remainder creamy white.

Legs: Femur of foreleg light rose, tibia deep rose. Short first joint of tarsus purple; second, third and fourth tarsal joints creamy white, purplish at joinings. Fifth joint purple-brown except at base, claws same color. Other legs creamy white. Narrow purple line at joinings of tarsal joints; claws and distal half of fifth tarsal joint purplish brown.

Wings: Fore wing yellowish brown on costal border, to R. Veins C, Sc, and R golden brown, other longitudinal veins and cross veins purplish brown, except in anal region. In hind wing, Sc and R purplish brown, other longitudinal veins yellowish white; cross veins purplish black. Outer margin not darker than rest of wing membrane; no conspicuous dark spots.

Abdomen: Creamy white background, segments 1–7; 8 faintly, 9 and 10 definitely yellow. Posterior border of each tergite creamy white. Tergites 1–6 with faint grey median streak; 7–10 with rather broad greyed lavender median streak. Oblique lateral grey-rose mark on each side of each tergite from near posterior border medially to anterior lateral angle. On 1, this is more brownish and occupies most of each side of the tergite, with extensions along the anterior border to median line. On 2–6, extensions to median line as in 1, but narrower; 6, lateral marks joined posteriorly. 7–9, marks arise as arms from broad median stripe, on 8 and 9 not reaching anterior margin. 10 with faint purple-brown lateral line. Ganglionic area on sternite 6–10 purplish brown; on 1–5 indicated only by a white circle. Faint indication of yellow median streak on 8 and 9, and of yellowish triangle on 7, its base on posterior border. No other ventral markings.

Tails: Joints reddish brown, darker distally, very dark at joinings. Proximal end of each creamy white to light tan. Extreme distal end of tails creamy white.

Genitalia: Of the *carolina* type. Basal joint of forceps limb equal to one-half of second joint. Second joint swollen distally; the two short end joints of medium size. Purplish black line on basal joint on outer side at base, and on inner side distally. Tip of second joint purplish, two distal joints brown. Penes with purple lateral stripe on outer margin. (Fig. 20).

FEMALE IMAGO.

Head: Yellowish—in life, sulphur-yellow. Markings as in male; second antennal joint brown.

Thorax: Pronotum greenish yellow with indistinct brown longitudinal stripes. Mesonotum flesh-colored, bordered by light brown. At base of wing in living specimen, two triangular olive patches. Metanotum yellow. Pleura and sternites flesh-colored, sutures yellow. In some specimens, mesosternum also yellow.

Legs: Yellow. On foreleg trochanter, spot on outer femur near distal end, and distal end of tibia, purplish rose. All joinings, claws and distal two-thirds of fifth tarsal joint purplish brown. Other legs with but indistinct lines of color at joinings, claws yellowish basally and dark grey distally; last tarsal joint as in foreleg.

Wings: Amber or yellow tinted throughout. Main longitudinal veins yellow to whitish, cross veins rose to purple.

Abdomen: Pale yellow when eggs have been deposited, flesh-colored to salmon-pink before this. Prominent median stripe on tergites 7–10 as in male, its narrow extension forward to tergite 1, yellow. In life, this median line on 8 is bordered with greenish, and posteriorly with sulphur-yellow spots near pleural folds. No green on 9, but more yellow. Markings of tergites very similar in position to those of male, but narrower and less extensive, in color dull lavender. Ventrally, ganglionic areas as in male, but purplish streaks on 6–10 very narrow or lacking. Sternites 8–10 sulphur-yellow.

Tails: Yellowish white, very indistinctly more grey at joinings.

Holotype: ♂, imago. Taken at Hamburg Lake, on Brush Creek, 10 miles north of Greensboro, N. C., June 6, 1929. No. 916.1, in C. U. collection.

Allotype: ♀, imago. Same place, same time. No. 916.2, in C. U. collection.

Paratypes: 1 ♂, 4 ♀s, imagoes; 1 ♂, 3 ♀s, subimagoes. Same place, same time. No. 916.3–.11, in C. U. collection.

Hexagenia carolina was first captured at Hamburg Lake, a small artificial lake owned by a local angling club. Shortly after 8 P. M., on June 1, as we were driving along the highway between Greensboro and Summerfield, a considerable number of large yellowsh female Hexagenias appeared, flying toward the headlights. On parking the car, it was discovered that no collecting net had been put in, but the big mayflies were flying so slowly and so close to the road that it was possible to capture many of them by hand, literally picking them out of the air as they passed. Many fell to the road and were crushed by passing autos. They were most numerous near the bridge

over the outlet of the lake. All taken that evening were subimago females.

Three days of cool weather were followed on June 6 by a warmer evening, and we returned to the lake, arriving in time to see many of the Hexagenias emerging from their nymphal skins at the surface of the water. They rose quite high almost at once, flying straight toward the tree tops. They could be taken only with the net, and the majority escaped it. When the lights of the car were turned on, two subimago males were taken, along with several more females. Another trip to the lake on June 7 yielded many more females and several males. On this evening also, we were able, by the use of a flashlight, to collect great numbers of nymphal skins, as they floated downstream toward the overflow on one side of the dam.

Many subimagoes of both sexes were kept until they attained the imago state. One male required 22 to 23 hours to complete its transformation, another male 23 to 24 hours. Three females varied from 22½ to 26½ in their subimaginal state.

Nymphs which seem to correspond identically with the nymph skins taken at Hamburg Lake were found in the mud along one bank of the South Toe River, near Micaville, N. C., on July 3, 1930. None of these transformed.

Hexagenia carolina (?) On the morning of June 27, 1929, a fine male was found on the door screen of a house at Franklin, N. C., on a bluff just above the Little Tennessee River. On the evening of July 3, two female subimagoes were taken as they arose from the river, and many others were seen but could not be captured. These two females were kept until they transformed into imagoes.

The females seem very similar to those taken at Hamburg Lake, but the male exhibits certain differences from the males of *H. carolina* taken at that lake. It differs in these respects: tails 55 mm. in length, light reddish brown with wide dark brown markings at joinings; distal end of second joint of forceps not swollen, as in typical *H. carolina;* ganglionic markings extend anteriorly to segment 4, indistinctly to 2; upper part of eye slate grey instead of golden brown.

When more specimens can be obtained, it may be apparent that these taken at Franklin are a different species. Meantime I leave them tentatively under *H. carolina*.

Hexagenia weewa, n. sp.

A large species, the females bright canary yellow, the males marked with purplish brown. Hind wing of male with purplish outer border and with dark spots.

MEASUREMENTS.

	Body	*Tails*	*Foreleg*	*Fore-wing*
Male imago (4 specimens)	22–24	55–67	17–19	17–19
Female imago (13 specimens)	24½–30	40–47	10–12½	24–28

MALE IMAGO.

Head: Yellowish white. Upper half of compound eyes purplish grey. Ocelli ringed at base with greenish, above this with a wider band of amber brown. Dorsal aspect of median carina brownish at tip, black in center. Second antennal joint and proximal portion of filament amber brown. Compound eye is to space between eyes approximately as 1:0.75.

Thorax: Pronotum light tan, longitudinal stripes purplish brown, extensions to wing base brown. Mesonotum creamy white bordered with brown. Metanotum yellowish. Pleura of mesonotum brown, other pleura yellowish to brownish. Prosternum anteriorly creamy white, posterior half very dark purplish brown. Anterior portion of mesosternum and all of metasternum dark purplish brown. Posterior of mesosternum lighter shade of same color.

Legs: Ventral of coxa and all of trochanter, femur, tibia and first tarsal joint of foreleg mahogany brown. Proximal half of tarsal joints two to four yellow; distal half purplish brown. Fifth tarsal joint and basal half of claws dark purplish brown, claws distally dark grey. Other legs yellowish white, very faint purple line at tarsal joinings. Claws pearl-grey ventrally, brownish dorsally. Fifth tarsal joint purplish brown except at base.

Wings: Costal margin of fore wing, to R, reddish brown. C, Sc and R brown, other longitudinal veins of both wings purplish brown. Cross veins purplish black. Hind wing with purplish outer margin, and several purplish black spots in usual area.

Abdomen: Ground color white, sometimes faintly tinted with lavender; 8–10 faintly yellowish. Tergites with well-defined median longitudinal streak. Wide and dark purple on 7–9, somewhat narrower on 1–6 and 10. On 1–6 greyish purple, bifid anteriorly. Purplish brown oblique lateral marks arise from anterior lateral angles of tergites 1–7, extending backwards and upwards, but not reaching posterior border. On 1 and 2 these marks are triangular, with base on pleural margin, and narrow extensions along the anterior border to median line. On 3–7 the triangular appearance gradually gives way to an elongated streak with pointed free ends. On 8 and 9 these marks are outward extensions of the median longitudinal stripe, and do not attain the anterior margin. 10 yellowish, with oblique lateral brownish bars.

Ventrally, the ganglionic area in each sternite marked with purplish black. An irregular lavender-brown triangle on sternites 1–9, becoming narrower on 8 and 9. Its apical third lighter lavender, defined laterally by two brown streaks. In center of each sternite, on each side of median line, a small clear round spot. Sternites 1–5 and 8, with narrow purple posterior border.

Tails: Basal joints light brown, dark brown at joinings. In remainder of tail, joints dark reddish brown, slightly darker distally, each with a narrow yellow proximal ring.

Genitalia: Of *carolina* type. Forceps base purplish brown. Basal joint of forceps limb on ventral side streaked with purple. Distal end of second joint, and both end joints, greyed lavender. Penes greyish, with purplish brown ventral streak. Remarkable for the great relative length of the second joint of the forceps limb, which is three-fifths the length of the first. The end-joints, especially the third, are likewise unusually long and stout. (Fig. 17).

FEMALE IMAGO.

Entire body clear canary yellow. Ocelli as in male. Median carina black at base and near distal end. Purplish-brown spot between ocellus and compound eye.

Thorax: Faint purplish-grey streak on pronotum. Pleurum and sternum of mesothorax flushed with orange.

Legs: Light yellow, first pair with lavender marks on trochanter, streak near base of femur, and mark near base of tibia, almost encircling it. Joinings of tarsus, and all but base of fifth tarsal joint, also blunt claw, dark purplish-brown. Pointed claw amber with purple mark. Claws and fifth tarsal joint of other legs similar. Faint purple line at tarsal joinings, no other marks.

Wings: Tinted throughout with clear amber yellow. Longitudinal veins in upper half of fore wing canary yellow, all others white to yellowish. Majority of cross veins purplish black.

Abdomen: Tergites with median longitudinal stripe and lateral oblique marks, much as in male, but latter less intense in color. On 7, the lateral mark arises from purple streak near posterior border of tergite and extends forwards and outwards. All tergites bordered posteriorly with white along central portion. Purple spot on anterior part of pleural fold on sternite 9. Ventrally, purplish black median line marks each ganglionic area.

Tails: Yellowish white, each joining with white proximal ring.

Holotype: ♂, imago. Taken at Chipola Lake, Fla., near the village of Weewa-hitchka, by Prof. J. G. Needham, April 8, 1927. No. 918.1, in C. U. collection.

Allotype: ♀, imago. Same as above. No. 918.2, in C. U. collection.

Paratypes: 3 ♂s, 13 ♀s. Same as above. No. 918.3–.17, in C. U. collection.

Of the collecting of *Hexagenia weewa*, Prof. Needham gives the following account:

"The capture of *Hexagenia weewa* occurred on this wise. Prof. C. R. Crosby and I were passengers on the Apalachicola River steamboat *John C. Callahan, Jr.* On the evening of the eighth of April, this big boat ventured up the Chipola River above Dead Lake to Cotton Bluff to take on some barrels of turpentine. Near Cotton Bluff the boat got stuck in one of the bends of that crooked little stream just at nightfall. The searchlight was turned on, and in the beam of light that it cast upstream the mayflies rose above the black waters by thousands. Along with multitudes of midges and a few other mayflies of the genus Ephemerella, the big yellow female Hexagenias came fluttering up to the light. They settled all over the front of the boat, two or three layers deep wherever there was support. They flew in our faces and clung to our clothing. One could gather them up by barrelsful. But among the many thousands of females, only two or three males were seen."

Hexagenia rosacea, n. sp.

A rather large species, superficially similar to *H. carolina* and *H. marilandica*. Distinguishable from the former by the brighter and more extensive color pattern, the shorter femur, and by the genitalia. From the latter it may be distinguished by the greater amount of color on the anterior abdominal tergites, the shorter second tarsal joint, and by the genitalia. The compound eye is also proportionately larger than in either of these species.

MEASUREMENTS.

	Body	*Tails*	*Foreleg*	*Fore-wing*
Male imago.....	20	50	12	17

MALE IMAGO.

Head: Greyish white. Median carina in dorsal aspect rose distally, base black. Upper portion of compound eye cream-colored. Ocelli with black ring at base, rose ring above this. Cream-colored markings on vertex. Filament of antenna rose, basal joints cream. Compound eye is to the space between the eyes approximately as 1:0.75.

Thorax: Pronotum greyish white, with two longitudinal purplish-red streaks extending to wing bases. Mesonotum whitish with cream-white markings, bordered by rose-brown. Metanotum yellow with rose markings. Prosternum white with faint lavender streak posteriorly. Mesosternum very deep rose, shading to light rose and with white posterior border. Metasternum purplish rose. Pleura white with lateral rose stripes to base of middle legs.

Legs: Coxa posteriorly in distal half, trochanter and femur of foreleg rose. Tibia deep rose. First short tarsal joint, and distal third

of second to fourth joints, very deep purplish rose. Fifth joint except at base, and claws, same color. Other legs white, tarsal joinings with narrow purplish line. Blunt claw and distal two-thirds of fifth joint of tarsus purplish grey, pointed claw lighter shade of same color.

Wings: Very iridescent. Costal margin of fore wing, to R, light brown in basal half, dark brown distally. Veins C, Sc, and R of fore wing golden brown, other longitudinal veins dark purple. Hind wing without dark outer margin.

Abdomen: Ground color white on segments 1–6, definitely yellow on 7–10. Dorsally, rather wide median stripe on all tergites, greyish brown on 1–5, reddish brown on 6–10; becomes progressively wider from 7–9. Tergites 1 and 2 dull rose-grey except for white mark near pleural fold, another on each side near anterior margin, and pinkish crescent on posterior margin at median line. 2–7 with deep rose oblique lateral stripes from anterior lateral angle to posterior margin, joining median stripe. Lateral stripe becoming wider on 6 and 7. Narrow extension along anterior margin halfway to median line. 3 with pink crescent as in 1 and 2. 4–9 with deep rose posterior border. 8 and 9, lateral mark becomes a short wide extension of median stripe from posterior margin, not attaining anterior margin. 10 bright yellow at bases of tails, brown oblique line on each side. Pleural folds white, yellowish on 8 and 9. Ventrally, ganglionic area marked in each sternite by dark rose streak. Sternite 1 with rose triangle, its base on posterior margin, its apex halfway to anterior margin. Sternites 2–10 bordered posteriorly with deep rose. On each side a small deep-rose triangle, base on posterior margin, extending forward less than half the length of each sternite.

Tails: Near base, each joint yellow proximally, deep rose in distal half, with wide reddish-black ring at joining. Near center of tail, joints yellow proximally, dark brown in distal two-thirds, darker at joining. More distally, joints dark brown throughout, save for narrow light proximal ring.

Genitalia: Of *carolina* type, the distal forceps joints somewhat less slender than in *H. carolina*. Forceps limbs golden yellow basally, becoming tinged with reddish brown on distal joints. Penes golden yellow, streaked longitudinally with rose-brown. (Fig. 10).

Holotype: ♂, imago. Taken on window screen at Penrose, N. C., near headwaters of French Broad River, July 14, 1930. No. 922.1, in C. U. collection.

Hexagenia orlando, n. sp.

A rather small species. Fore wing of male with reddish brown costal border; narrow purplish outer margin on hind wing. Ground color of abdomen of male yellow to light tan, with dark brown markings. Female marked in purple.

MEASUREMENTS.

	Body	*Tails*	*Foreleg*	*Fore-wing*
Male imago (12 specimens)	14–18	36–45	9–13	11–14
Female imago (1 specimen)	17	21	?	15

MALE IMAGO.

Head: Upper part of compound eye golden brown. Ocelli with greyish-black basal ring and purplish brown ring above this. Second antennal joint purplish brown, filament light brown. Vertex marked with greyish purple near center, with orange laterally and posteriorly. Occiput purplish, an orange mark on each side next to compound eye. Dorsal aspect of median carina dark purplish, grey at tip. Diameter of compound eye is to space between eyes approximately as 1:0.75.

Thorax: Pronotum light tan, longitudinal stripes dark purple-brown. Mesonotum yellowish tan, greenish centrally, in the anterior three-fourths. Brown spot in center in posterior fourth. Bordered laterally and posteriorly with golden brown and cream. Metanotum yellowish brown with cream markings centrally and posteriorly. Pleura yellowish to golden brown with cream markings; sutures brown. Anterior half of prosternum yellow, posterior half dark brown with purplish streak between legs. Meso- and metasternum golden brown laterally, and on posterior of mesosternum; medially reddish brown. Posterior of mesosternum bordered with reddish brown.

Legs: Coxa and trochanter of foreleg dark brown; femur and tibia dark reddish brown, darker at joinings. First tarsal joint dark brown; second to fourth yellow basally, purplish brown distally. Fifth tarsal joint and claw purplish brown. Other legs yellow. Joinings of tibia and tarsus and of all tarsal joints, also claw and fifth tarsal joint, purplish brown.

Wings: Fore wing with reddish brown costal border. Hind wing with narrow purplish brown outer margin. In fore wing a few cross veins narrowly margined with purplish black; in hind wing, several widely margined. Longitudinal veins in both wings golden brown, cross veins purplish black.

Abdomen: Ground color yellow to light tan, becoming deep yellow on segments 8–10. Median dorsal line with rather broad blackish-brown stripe on tergites 6–9, and with narrower dark grey streak on 1–5, in these latter tergites wider anteriorly. On 10 this median line is narrow and black. On 1–7, an oblique lateral band arises at the anterior lateral angle and extends backwards and inwards to join the median stripe at the posterior margin. Each of these bands is wide anteriorly, narrow posteriorly, except on 7, where the reverse is true. On 8 and 9 these marks arise from the center of the median stripe at the posterior border, and occupy the entire posterior lateral angle. A narrow extension may continue up along the pleural fold to the anterior margin. Ventrally, a purplish-brown streak marks each ganglionic area; another similarly-colored faint mark occurs in each anterior lateral angle of sternites 1–8. Sternite 1 may show two

clear round spots in center, one on each side of the median line. On 9, an orange triangle with base on posterior margin, extends to anterior margin. On 1–8, the sides of similar triangles are faintly indicated as brown slightly wavy lines.

Genitalia: Of the *carolina* type, quite slender, the second joint of the forceps limb slightly more than twice as long as the first joint. Forceps base and first joint of forceps limb amber brown with cream markings. Second joint greyish white in basal half, purplish brown distally. End joints light purplish brown, dark brown at joining. Penes dark brown ventrally, yellow dorsally. (Fig. 13).

Tails: At base, each joint yellow proximally and light brown distally, dark brown at joinings. In all the remainder of the tail except at tip, each joint dark reddish brown with narrow proximal yellow ring, joinings dark brown to black. At tip, joints light brown, joinings black.

Female Imago.

Head: Yellow. Upper part of compound eye dark grey. Occiput and vertex mottled with dark brown. Ocelli ringed with black at base, and black spot laterally next to compound eyes. Dorsal aspect of median carina black. Antennal filament light brown.

Thorax: Pronotum yellowish with purplish-brown longitudinal stripes. Mesonotum straw yellow bordered with darker yellow, and with grey markings. Metanotum yellow marked with black. Pleura cream to light yellow. Prosternum light yellow, dark streak between legs. Meso- and metasterna brighter yellow, no definite markings.

Legs: Foreleg missing, from only specimen available. Other legs straw yellow; the claws, fifth tarsal segment and joining of other joints of tarsus, faint greyed lavender.

Wings: Fore wing with faint yellow costal border. Longitudinal veins of both wings golden yellow, cross veins purplish brown.

Abdomen: Creamy white, yellowish on 8–10. Tergites with greyed purple markings, somewhat as in male. Wide median band on tergites 6–10, on 6 and 7 expanding anteriorly and giving off two lateral arms toward center of each side of tergite. Same median band on 1–5, but not so wide, expanded in the anterior half and the lateral fan-shaped arms more prominent (except in 1) than on 6 and 7. Lateral oblique stripes arise from anterior lateral angles of tergites 1–7, expand widely in center of each side, becoming narrower as they join the median band at the center of the posterior border. On 1 and 2 these stripes are so wide as almost to obliterate the white triangle in the posterior lateral angle. On 8–10 these stripes arise from the posterior median line as extensions of the median stripe, proceeding forwards and outwards to pleural fold; a narrow line may then extend along pleural fold to anterior border. Ventrally, each ganglionic area is indicated by a purplish-black triangle or streak. On 10, two oblique black lines on each side of center of sternite. No other ventral markings.

Tails: Greyish white, marked at each joining with dark maroon.

Holotype: ♂, imago. Taken at Orlando, Fla., by Mr. M. D. Leonard, May 20, 1927. No. 919.1, in C. U. collection.

Allotype: ♀, imago. Same location and collector, June, 1926. No. 919.2, in C. U. collection.

Paratypes: 11 ♂s. Same as holotype. No. 919.3–.13, in C. U. collection.

KEY TO HEXAGENIA MALES.

1. Both wings suffused throughout with bronze.....**H. recurvata**
   Wings in large part hyaline..... 2
2. Costal margin of fore-wing light brown in proximal half, dark brown distally; hind wing heavily bordered with purplish brown along outer edge, this border occupying approximately one-fourth the length of the wing.....**H. atrocaudata**
   Wings not as above..... 3
3. Costal border of fore-wing heavily bordered with brown; hind wing with evident brown outer margin, but this border not occupying one-fourth of the wing..... 4
   Hind wing lacking brown border on outer margin; fore wing usually with costal margin darker than rest of wing.....11
4. Fore wing under 15 mm. in length..... 5
   Fore wing over 15 mm. in length..... 7
5. Both wings definitely tinged with yellow or greenish yellow.....**H. venusta**
   Wings not tinged with yellow or greenish yellow..... 6
6. Fore wing under 13 mm. in length; both fore and hind wings with numerous dark spots.....**H. elegans**
   Fore wing over 13 mm. in length; fore wing lacking dark spots.....**H. mingo**
7. Bilineata type of genitalia; both wings tinged with light brown..**H. bilineata**
   Genitalia and wings not as above..... 8
8. Rigida type of genitalia; abdominal tergites each with two bright yellow triangular spots based on the anterior margin.....**H. rigida**
   Genitalia and abdominal markings not as above..... 9
9. Carolina type of genitalia; abdominal tergites whitish with oblique purplish brown markings.....**H. weewa**
   Limbata type of genitalia; abdominal tergites dark brown with paler markings.....10
10. Fore wing 18 mm. in length; costal margin dark red-brown throughout; eye unusually large.....**H. viridescens**
    Fore wing 17 mm. in length; costal margin yellowish brown, lighter in proximal half; eye not unusually large.....**H. occulta**
11. Both wings tinted almost uniformly with light bistre-grey; costal margin of fore wing distinctly bistre-grey.....**H. munda**
    Wings not uniformly tinted with grey; costal margin of fore wing brown....12
12. Fore wing not exceeding 15 mm. in length.....**H. orlando**
    Fore wing exceeding 15 mm. in length.....13
13. Wings tinted lightly with greenish yellow.....**H. limbata**
    Wings not tinted with greenish yellow.....14
14. Fore wing over 19 mm. in length; abdominal tergites dark brown, marked on each side with yellow spots not based on the anterior margin, **H. affiliata**
    Fore wing under 19 mm. in length; abdominal tergites whitish with rose to red markings.....15
15. Fore and hind wings with dark spots; anterior abdominal tergites without median stripe.....**H. marilandica**
    No spots in fore wing, few in hind wing; anterior abdominal tergites with median purplish-brown stripe.....**H. rosacea**

KEY TO HEXAGENIA FEMALES.

(NOTE.—Females of **H. munda** and **H. rosacea** not included.)

1. All principal longitudinal veins, and majority of cross veins, of both fore and hind wings, heavily bordered with dark reddish brown....**H. recurvata**
   Wings not as above.... 2
2. Outer margin of hind wings and costal margin of fore wings bordered with brown.... 3
   No brown border on outer margin of hind wings; fore wings may have brown or yellow costal margin.... 6
3. Fore wing under 20 mm. in length.... 4
   Fore wing over 20 mm. in length.... 5
4. Hind wing heavily bordered with purplish brown; costal margin of fore wing dark brown in distal half, light brown in proximal half...**H. atrocaudata**
   Hind wing narrowly bordered with reddish brown, and with numerous dark spots; costal border of fore wing dark brown in proximal half, light brown in distal half....**H. rigida**
5. Fore wing over 25 mm. in length; hind wing faintly bordered with greyish brown....**H. viridescens**
   Fore wing under 25 mm. in length; hind wing with prominent brown border, and with several distinct black spots....**H. bilineata**
6. Wings tinted throughout with yellow or greenish yellow.... 7
   Wings not definitely tinged with greenish yellow or yellow throughout.... 9
7. Fore wing under 24 mm. in length.... 8
   Fore wing over 24 mm. in length....**H. weewa**
8. Fore wing tinged with greenish, especially on costal border. Several cross veins near base of Sc and R margined with brown....**H. elegans**
   Both wings strongly tinged with greyish yellow. Cross veins near base of Sc and R not margined with brown as above....**H. venusta**
9. Fore wing 23 mm. or over....10
   Fore wing under 23 mm....11
10. Main cross veins and portions of many principal longitudinal veins of both wings rose-colored....**H. carolina**
    Main cross veins of both wings purplish black. Veins C, Sc and R of fore wing, and Sc of hind wing, light brown; other longitudinal veins grey....**H. marilandica**
11. Fore wing 20–22 mm. in length....12
    Fore wing less than 20 mm. in length....**H. orlando**
12. Costal border of fore wing reddish brown; cross veins purplish rose....13
    Costal border of fore wing yellowish; cross veins purple-black....14
13. Wing 22 mm. in length; abdomen marked with very dark red-brown, **H. affiliata**
    Wing 20 mm. in length; abdomen marked with purplish brown....**H. occulta**
14. Veins C and Sc yellowish, other veins greyish white....**H. limbata**
    Vein C amber; other longitudinal veins in upper part of fore wing purplish brown....**H. mingo**

TABULATION OF CHARACTERS.

HEXAGENIA MALES.

SPECIES	Gen.	Wing	F : tb	Tb : t	T. jts.	Th.	Abdom.	Pattn.	Eye	F. lg : body
recurvata	III	15–18	1:2	1:1	1:1.2	dark brown	yellow	light brown	yellow tan	1:1.4
atrocaudata	V	19½	1:1.7	1:1	1:1	v. dark brown	yellow	dark brown to bl.	orange	1:2
bilineata	II	16	1:1.6	1:1.5	1:1.3	v. dark brown	red-brown	dark brown to bl.	dark brown	1:1
limbata	I	13–15	?	?	?	?	yellow	dark brown	green-yellow	?
rigida	IV	16	1:1.9	1:1.5	1:1.1	dark brown	yellow	dark brown	dark brown	1:1.4
viridescens	I	18	1:1.7	1:1.3	1:1.2	v. dark brown	dk.red-brown	light brown	dark brown	1:1
affiliata	I	19½	1:1.6	1:1.2	1:1.2	dark red	yellow	dark brown to bl.	dark green brown	1:1.4
occulta	I	17	1:1.7	1:1.2	1:1.3	dark red-brown	red-brown	dark red-brown	v. dark brown	1:1
munda	I	14	?	?	?	brown	yellow	brown to bl.	?	?
venusta	I	13–16	1:1.8	1:1.2	1:1	dark purple brown	yellow	purple brown	dark grey	1:1.3
carolina	VI	14–17	1:1.2	1:1.5	1:1.1	red-brown	creamy white	greyed rose	golden brown	1:2
rosacea	VI	17	1:1.7	1:1.3	1:1.1	dark red	creamy white	deep rose	cream	1:1.7
marilandica	VI	16	1:1.7	1:1.4	1:1.5	dark red	creamy white	deep rose	slate grey	1:1.7
mingo	I	14½	1:1.7	1:1	1:1	dark brown	creamy white	red-brown	cream	1:1.5
orlando	VI	12–14½	1:2	1:1	1:1.2	light tan	light tan	dark brown	golden brown	1:1.5
elegans	VI	10–12	1:1.5	1:1.2	1:1.2	purple rose	creamy white	deep rose	golden tan	1:1.7
weewa	VI	17–19	1:1.9	1:1.4	1:1.2	purple brown	white	dark purple brown	purple grey	1:1.2

EXPLANATION OF ABBREVIATIONS USED IN TABULATION OF CHARACTERS.

Gen.—genitalia type.
I—type limbata.
II—type bilineata.
III—type recurvata.
IV—type rigida.
V—type atrocaudata.
VI—type carolina.
Wing—length of fore wing.
F : tb.—proportionate length of femur to tibia.
Tb : t—proportionate length of tibia to tarsus.
T. jts.—proportionate length of 3rd to 2nd tarsal joints.
Th.—color of thoracic sternites.
Abdom.—general groundcolor of abdomen.
Pattn.—general color pattern of abdomen.
Eye—color of upper portion of compound eye.
F. lg:body—proportionate length of fore leg to body.

THE NYMPHS.

A comparative study of eleven species of Hexagenia nymphs seems to indicate that only a few of the external structures show sufficient variation between species to serve as a basis for classification. Of these, the most important are (1) the shape of the frontal process of the head, and (2) the mandibular tusks. Of secondary importance are (1) the maxillæ, (2) the claws, and (3) the tails. In one species only, *H. recurvata*, the structure of the antennæ and the first rudimentary pair of gills serve as distinctive characters. The color of the body, the color pattern, and the color of gills and tails may be useful to supplement structural differences.

The frontal process may be square-cut or truncate, as in *H. atrocaudata*, (see plate, Fig. 1, d); angular, as in *H. recurvata*, (plate, Fig. 1, b); conical, as in *H. carolina* (plate, Fig. 1, c); or dome-shaped, as in *H. mingo* (plate, Fig. 1, a). In some species, as in Nymph No. 3, this process may be dome-shaped in the female and conical in the male. In the tabulation of nymphal characters, the head of the female has been considered, and any variations in the frontal process of the male are indicated in the brief description of each species.

The relative length of the head and of that portion of the tusks protruding beyond it is indicated for male and female in the tabulation. The tusks of the female are larger and longer than those of the male. Since, however, the head of the female is likewise wider and longer than that of the male, the relative length of tusk protruding beyond the head may be greater in the case of the male. The amount of curvature of the tusks is also characteristic. These show the least curvature in *H. recurvata*, in which species they are likewise provided with long hairs from base to tip, on the outer margin. The tusks of the other nymphs studied have hairs on the outer margin only in the basal half, the distal half being hairy on the inner margin only. The tusks of *H. carolina* are the longest.

The relative length of the maxillary palp to that of the entire length of the maxilla, and of the length of its first joint to the galea-lacinia, seem to be fairly constant specific characters. The third claw has been considered as being the least subject to injury and other modifications from external sources. Figures of the third claw of each species are given (Figs. 2, 3, 8, 9),

and show specific variations. The outer tails are stouter than the middle one, in all these species, and in most cases slightly shorter. In *H. bilineata* the tails of the male are proportionately much longer than those of the female. The color of the tails, and the presence or absence of darker rings at the joinings, seem to be specific.

In *H. recurvata*, the antennæ have only short inconspicuous hairs throughout their entire length, while in all the other species the antennæ possess very long hairs in that region from near the base to beyond the middle, and very short hairs at the tip. In *H. recurvata* likewise, the first rudimentary gill is simple, not bifid as in all the others.

DESCRIPTION OF NYMPHS.

Hexagenia bilineata.

Tusks reddish brown, gently upcurved in distal half. First joint of maxillary palp shorter than galea-lacinia. Palp less than twice length of body of maxilla. Outer tails banded indistinctly at joinings with greyish red-brown. Tails of males proportionately longer than those of females. Head and pronotum dark red-brown. Meso- and metathorax and legs red-brown. Abdominal tergites pinkish grey, each margined and bordered with grey and marked with red-brown. Ventrally light red-brown. Gills red-brown in center, fringes reddish grey. Body long and slender. Claws long and slender, not curved at tip; base slightly swollen.

Distribution: Iowa—Fairport, Andalusia Chute, Keokuk.

Hexagenia recurvata.

First rudimentary pair of gills simple, not bifid as in other species. Tusks red-brown; short and stout, only slightly upcurved. Fringed with long hairs on entire outer margin. First joint of maxillary palp equal in length to galea-lacinia. Palp less than twice length of body of maxilla. Middle tail greyish white. Head and pronotum light red. Meso- and metanotum darker red. Legs yellowish tinged with red. Abdominal tergites red-brown, margins and joinings light tan. Gills dark purplish grey in center, fringes light purplish grey. Anterior abdominal segments and thorax stout. Head and posterior abdominal segments relatively slender. Claws moderately stout, swollen at base, tip slightly curved.

Distribution: New York—McLean, Freeville, Michigan Hollow; Massachusetts—Granby; West Virginia—Moore's Creek at Wardensville; Michigan—Marquette Co.

Hexagenia atrocaudata.

Tusks red-brown, very dark distally; curve outward and downward basally, strongly upward distally. First joint of maxillary palp longer than galea-lacinia. Palp twice the length of body of maxilla. Middle tail yellowish. Head, dorsum of thorax, legs and last two abdominal tergites yellow-brown margined and marked with yellow. Anterior abdominal tergites and ventral surface grey-white, tinged with lavender. Gills very dark purple in center, fringes dark grey-purple. Body stout. Claws broad and short, swollen at base; tip slightly curved.

Distribution: New York—Ithaca (Beebe Lake). Reared by Prof. J. G. Needham. Indiana—Howe; West Virginia—'Smoke Hole,' Wardensville, Athens, Greenbrier River, Marlinton.

Hexagenia carolina.

Tusks red-brown, darker distally. Very long, almost equalling front leg in length. Upcurved distally. First joint of maxillary palp equal to or slightly longer than galea-lacinia. Palp not quite twice length of body of maxilla. Middle tail very light yellow. Head and dorsum of thorax yellow-brown. Abdominal tergites greyish lavender margined with white. Ventral surface white. Gills dark purple in center, fringes dark greyish purple. Body moderately stout. Claws short and stout, swollen at base; very short pointed tip, slightly curved.

Distribution: North Carolina—Hamburg Lake, near Greensboro, South Toe River, at Micaville.

Hexagonia mingo.

Frontal process tending toward conical, in some males. Tusks yellowish brown, extreme tip dark red-brown. Medium in length, only slightly upcurved. First joint of maxillary palp shorter than galea-lacinia. Palp almost twice length of body of maxilla. Outer tails of male grey-lavender at joinings, these bands at base alternately wide and narrow. Middle tails of both sexes white. Head and dorsum of thorax red-brown. Legs creamy white. Abdominal tergites creamy white, marked with purplish grey. Ventrally creamy white. Gills dark grey-purple in center, fringes lighter grey-purple. Body rather slender. Claws rather slender, base very little swollen. Tip somewhat curved.

Distribution: West Virginia—Millwood, reared by Prof. J. G. Needham.

Nymph No. 1.

Tusks yellowish brown; extreme tip dark red-brown. Medium in length, upcurved at tip. First joint of maxillary palp almost equal to galea-lacinia. Palp less than twice length of body of maxilla. Outer tails of male light grey with purplish-black joinings. Middle tail of male, and all tails of female, light yellow. Head and dorsum of thorax dark brown in male, in female slightly lighter. Abdominal tergites white; in male marked with purplish brown, in female with light grey.

Ventrally creamy white; dark ganglionic streaks on sternites 6–9, less distinct in female. Gills bluish purple in center, fringes same. Body stout. Claws short and stout, swollen at base; tip slightly curved.

Distribution: West Virginia—Wheeling, Grass Lick Run; Virginia—Mountain Lake.

Nymph No. 2.

Note: These specimens not fully matured.

Tusks yellowish brown, extreme tip very dark brown. Medium in length. Rather strongly upcurved distally. First joint of maxillary palp equal to galea-lacinia. Palp almost twice length of body of maxilla. Middle tail white. Head light yellow-brown. Thorax and legs creamy white. Abdominal tergites bluish white marked with purplish grey. Ventrally creamy white. Gills light purple-grey in center, fringes same color but lighter. Body very slender. Claws very slender and long.

Distribution: North Carolina—Pacolet River, near Tryon.

Nymph No. 3.

Note: Markings of these nymphs are strikingly similar to the color pattern of mature *H. rigida.*

Frontal process of male conical. Tusks light red-brown throughout length. Medium in length, gently upcurved. First joint of maxillary palp shorter than galea-lacinia. Palp less than twice length of body of maxilla, which is quite stout. Middle tail yellowish white. Head and dorsum of thorax red-brown. Legs yellow. Abdominal tergites purplish brown, marked and margined posteriorly with cream. Ventrally, thorax grey-white. Abdominal sternites cream, with dark ganglionic streaks on 6–9 in female. Gills purplish-black in center, fringes dark purple-grey. Body long and slender. Claws rather short, fairly slender, not swollen at base.

Distribution: Michigan—Alcona Co.

Nymph No. 4.

Tusks greyish yellow, dark red-brown at extreme tip. Medium in length, gently upcurved. First joint of maxillary palp almost equals galea-lacinia. Palp less than twice length of body of maxilla. Middle tail white. Head and dorsum of thorax light brown. Legs white. Abdominal tergites bluish white marked with purplish grey. Ventrally white; with dark ganglionic streaks on 6–9 sternites of both sexes. Gills dark purple-grey in center, fringes very light purple-grey. Body slender. Claws very long and slender.

Distribution: Florida—Gainesville and Torreya.

Nymph No. 5.

Note: Of this species, female specimens only.

Tusks yellowish brown basally; distal half red-brown. Medium long, upcurved distally. First joint of maxillary palp almost equals

galea-lacinia. Palp equal to twice length of body of maxilla. Middle tail white. Head and dorsum of thorax light yellow-brown. Legs cream. Abdominal tergites cream-white marked with purplish grey. Ventrally cream-white, with purplish ganglionic streak on sternites 7–9. Gills dark purple-grey in center, fringes lighter purple-grey. Body medium stout. Claws long and slender; not swollen at base.

Distribution: Florida—Gainesville.

Nymph No. 6.

Frontal process rather conical in male. Tusks yellowish, distal half reddish. Medium long, sharply upcurved distally. First joint of maxillary palp approximately equal to galea-lacinia. Palp less than twice length of body of maxilla. Middle tail creamy white. Outer tails of male dark brown with wide dark purplish-brown joinings. Head of male very dark red-brown, dorsum of thorax lighter red-brown. Head and thorax of female light brown. Abdominal tergites of male yellow with reddish-brown markings; of female, white with lavender-grey markings. Ventral of thorax light tan. Sternites of abdomen creamy white with purplish-black ganglionic streaks on 6–9. Gills light grey-lavender in center, fringes same. Body medium slender. Claws rather stout, swollen at base; only slightly curved.

Distribution: North Carolina—Tuckaseegee River, at Jackson.

KEY TO ELEVEN SPECIES OF HEXAGENIA NYMPHS.

1. Frontal process angular; first rudimentary gill simple.....*H. recurvata*
   Frontal process not angular; first rudimentary gill bifid..... 2
2. Frontal process square-cut or truncate.....*H. atrocaudata*
   Frontal process not truncate..... 3
3. Frontal process conical..... 4
   Frontal process dome-shaped or rounded..... 6
4. Body of female exceeding 30 mm. in length; body of male 23 mm. or longer.....*H. carolina*
   Body of female less than 30 mm.; of male, less than 23 mm..... 5
5. Tails of male longer than those of female; outer tails and body red-brown.....*H. bilineata*
   Tails of male not exceeding those of female; tails and body creamy white.....*Nymph No. 2*
6. Third claw short and stout, much swollen at base..... 7
   Third claw long and slender, little if any swollen at base..... 8
7. Tarsus as wide as greatest width of claw; abdomen of male white, outer tails light grey.....*Nymph No. 1*
   Tarsus narrower than greatest width of claw; male abdomen yellow, outer tails dark brown.....*Nymph No. 6*
8. Outer tails of male ringed at joinings with darker color.....*H. mingo*
   Outer tails of male not ringed at joinings with darker color..... 9
9. Body of female exceeding 25 mm. in length.....10
   Body of female less than 25 mm. in length.....*Nymph No. 4*
10. Abdominal tergites purplish brown with cream markings; palp less than twice body of maxilla.....*Nymph No. 3*
    Abdominal tergites white with purplish grey markings; palp equal in length to twice body of maxilla.....*Nymph No. 5*

TABULATION OF CHARACTERS OF NYMPHS.

Species	Body of Male	Body of Female	Outer Tail Male	Outer Tail Female	Hd. vs. Tusk, Male	Hd. vs. Tusk, Female	Frontal Process	Outer Tail
atrocaudata	23–28	27–35	9–11	9–11	2½ : 2½	2½ : 3½	square	yellow
bilineata	15–22	21–26	9–11	7–8½	2 : 3	2½ : 3½	conical	light red-brown
carolina	23–28	32–36	8–12	11–14	2 : 4	3 : 5	dome	yellow
mingo	16½–21½	25–27	8–10	9	2 : 2½	3 : 3½	dome	white
recurvata	20–25	25–29	11–13	12–14	2 : 2	2½ : 2½	angular	purple-brown
No. 1	21–21½	27–32	9	10–11	2 : 2½	3 : 4	dome	♂ light grey ♀ yellow
No. 2*	17–19	18–21	5½	5½	1¾ : 2¼	1½ : 2	conical	white
No. 3	20	27	7	9–10	2 : 3	3 : 3	dome	yellow
No. 4	16*	17–19½	7	6–8	1½ : 2½	2 : 3	dome	white
No. 5		27		9		2 : 2½	dome	white
No. 6	18–22½	*25–26	6½–8	7–8	2 : 2½	2 : 3	dome	♂ brown ♀ white

EXPLANATION OF TABULATION:

All measurements given in millimeters. Blank spaces mean no specimens. For shape of frontal process, see figures. *=specimens not yet fully mature.

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EXPLANATION OF PLATE.

Genus Hexagenia.

Fig. 1. Frontal processes of heads of female nymphs. a—*H. mingo*. b—*H. recurvata*. c—*H. carolina*. d—*H. atrocaudata*.

Fig. 2. Third claws of nymphs. a—Nymph No. 5. b—Nymph No. 4. c—Nymph No. 3. d—Nymph No. 1.

Fig. 3. Maxillæ of female nymphs. a—Nymph No. 1. b—*H. recurvata*. c—Nymph No. 2. d—Nymph No. 4. e—*H. bilineata*. f—Nymph No. 6. g—Nymph No. 3.

Fig. 4. Head of nymph, *H. recurvata*.

Fig. 5. Head of nymph, *H. carolina*.

Fig. 6. Mandibular tusks of female nymphs. a—Nymph No. 1. b—*H. recurvata*. c—Nymph No. 2. d—Nymph No. 4. e—*H. bilineata*. f—Nymph No. 6. g—Nymph No. 3.

Fig. 7. Third claws of nymphs. a—*H. mingo*. b—Nymph No. 6. c—*H. atrocaudata*. d—*H. recurvata*. e—*H. carolina*.

Fig. 8. Third claw of *H. bilineata*.

Fig. 9. Third claw of Nymph No. 2.

Fig. 10. Male genitalia, *H. rosacea*.

Fig. 11. Male genitalia, *H. elegans*.

Fig. 12. Male genitalia, *H. atrocaudata*.

Fig. 13. Male genitalia, *H. orlando*.

Fig. 14. Male genitalia, *H. bilineata*.

Fig. 15. Mandibular tusks of female nymphs. a—*H. mingo*. b—Nymph No. 5. c—*H. atrocaudata*. d—*H. carolina*.

Fig. 16. Male genitalia, *H. rigida*.

Fig. 17. Male genitalia, *H. weewa*.

Fig. 18. Male genitalia, *H. recurvata*.

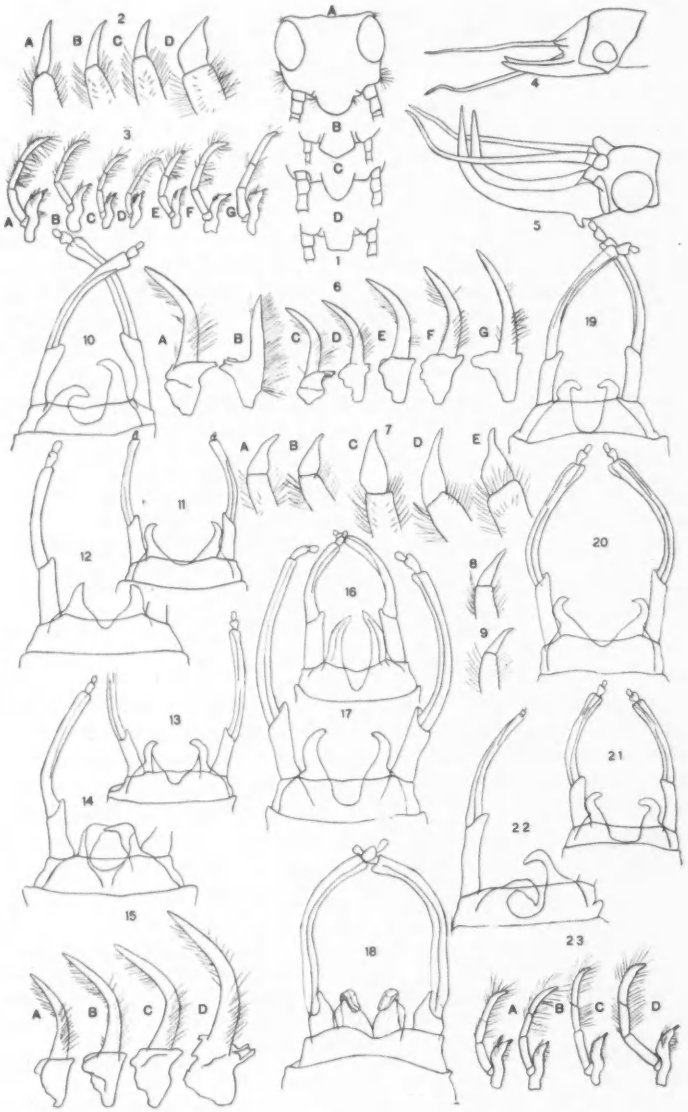
Fig. 19. Male genitalia, *H. limbata*.

Fig. 20. Male genitalia, *H. carolina*.

Fig. 21. Male genitalia, *H. mingo*.

Fig. 22. Male genitalia, *H. marilandica*.

Fig. 23. Maxillæ of female nymphs. a—*H. mingo*. b—Nymph No. 5. c—*H. atrocaudata*. d—*H. carolina*.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NEW SPECIES OF CRANE FLIES FROM SOUTH AMERICA. PART V.*†

(Family Tipulidæ, Order Diptera.)

CHARLES P. ALEXANDER,
Amherst, Massachusetts.

The majority of the species herein described as new were collected in *Colombia* by Mr. Fred W. Walker, chiefly at Vista Nieve on Mount Santa Marta. All such resulting types have been returned to the Museum of Zoology of the University of Michigan. One additional species was likewise taken on Mount Santa Marta by my friend, Dr. George Salt. The other species considered are from *Brazil*, collected by the veteran naturalist, Mr. Friedrich Schade, and from *Chile*, where they were taken in the Province of Malleco by Professor D. S. Bullock. Except where indicated above, the types of the novelties are preserved in my own collection. I wish to thank the gentlemen above mentioned very sincerely for this appreciated co-operation in making known the rich Tipulid fauna of the Neotropics.

Macromastix Osten Sacken.

Macromastix (Araucomyia) bullocki sp. n.

General coloration shiny yellow, the praescutum with reddish stripes; antennae of both sexes very short, 10-segmented; femora brownish yellow, the tips narrowly brownish black; wings grayish subhyaline, the stigma and a confluent seam on the anterior cord dark brown; abdomen yellow, lined longitudinally with black, the latter areas very extensive on the sternites.

Male.—Length, about 11 mm.; wing, 12 mm.

Female.—Length, about 15 mm.; wing, 14-14.5 mm.

Frontal prolongation of head obscure yellow, darker on sides, the nasus elongate; palpi black. Antennæ 10-segmented, unusually short in both sexes, a little longer than the head, excluding the frontal prolongation; first scapal segment brownish-yellow, the second clearer

*Contribution from the Entomological Laboratory, Massachusetts State College.

†The preceding part under this general title was published in these ANNALS in 1930 (XXIII: 721–740).

yellow; flagellum black; flagellar segments elongate-cylindrical, the verticils of the basal segments short, on the outer segments becoming more elongate, exceeding the segments. Head pale brown above, the posterior orbits clear yellow.

Pronotum light yellow, restrictedly infuscated medially. Mesonotal praescutum nitidous, deep yellow, with four narrow dark reddish stripes, the intermediate pair blackened on their anterior portions; median region of scutum yellow, the lobes more reddish; scutellum yellowish-testaceous; postnotal mediotergite yellow with two reddish brown longitudinal areas. Pleura nitidous, yellow, variegated with reddish areas. Halteres pale, the knobs infuscated. Legs with the fore coxæ yellow, lined with reddish, the other coxæ darker; trochanters brownish yellow; femora brownish yellow, the tips narrowly brownish black; tibiæ and tarsi obscure yellow, the latter passing into dark brown; claws (♂) with a basal tooth. Wings grayish subhyaline, cells *C* and *Sc* more yellowish; stigma and a connecting cloud on the anterior cord dark brown; wing-tip vaguely infumed; a dark seam in cell *M* along vein *Cu;* veins black, more yellowish in the costal region. Macrotrichia of veins small and inconspicuous. Venation: R_{1+2} diverging strongly from R_3, paralleling the free tip of Sc_2; cell M_1 with the petiole longer to shorter than *m*.

Abdominal tergites obscure yellow, with a narrow median black vitta; sternites similar, trivittate with black, the median stripe very wide, restricting the ground-color to narrow sublateral lines; hypopygium obscure yellow. Male hypopygium with the lateral lobes of the tergite very long and slender, separated by a deep notch; the fused basistyles and sternites similarly long and slender. Ovipositor with all valves very long and slender, straight.

HABITAT: Chile. *Holotype*, ♂, Nahuelbuta, near Angol, Malleco, among Chilean Pines, *Araucaria imbricata* Pav., altitude 800 meters, March 9, 1929 (D. S. Bullock). *Allotopotype*, ♀, altitude 1,200 meters, March 10, 1929. *Paratopotype*, a teneral ♀, with the allotype.

Macromastix (*Araucomyia*) *bullocki* is named in honor of the collector, Professor Dillman S. Bullock. The species is very different from *M.* (*A.*) *paulseni* (Phil.) in the short antennae of the male and all details of coloration and structure. The polished yellow and rusty coloration of the thorax is very suggestive of certain species of *Nephrotoma*.

Tipula Linnaeus.

Tipula laterosetosa sp. n.

Ground-color of mesonotum obscure yellow, the praescutum with four brown stripes that are narrowly bordered by darker brown; antennae short in both sexes, the flagellum bicolorous;

pleura variegated yellow and brown; femora with a broad yellowish white subterminal ring; tibiae brown, the bases narrowly pale yellow; wings grayish brown, variegated by dark brown and cream-yellow areas, the latter including a W-shaped mark across the outer ends of cells *R* and *M*, and a series of small marginal spots in the medial to anal fields; male hypopygium with a lateral pencil of yellow setae on either side of tergite; ninth sternite bearing two approximated cylindrical lobes on the mid-line.

Male.—Length, about 21 mm.; wing, 21.5 mm.

Female.—Length, about 25 mm.; wing, 24 mm.

Frontal prolongation of head brownish yellow, the nasus elongate, concolorous; palpi brownish black. Antennæ relatively short in both sexes; scape yellow; flagellar segments bicolorous, the basal enlargement brownish black, the remainder yellow; on outer segments the coloration becomes more brownish yellow; verticils much longer than the segments. Head buffy-yellow, on the posterior vertex trivittate with slightly darker brown, including a median vitta and a similar line on the posterior orbits; median region of anterior vertex produced into a small rounded papilla.

Mesonotal praescutum obscure yellow, with four light brown stripes that are narrowly bordered by dark brown; humeral region yellow, enclosing a small black marginal spot; posterior inter-spaces appearing as elongate pale yellow triangles; a shallow crescent-shaped brown area at suture; scutal lobes with centers brownish testaceous, encircled with dark brown, the median area testaceous, variegated by brown behind; scutellum dark brown, the parascutella similar, with a pale central spot; postnotal medio-tergite gray, with a capillary brown median line that becomes more expanded on the caudal margin. Pleura light yellow, variegated by transverse brown areas on sternopleurite and anepisternum, the latter broader and forming part of a more or less interrupted longitudinal stripe extending from the cervical sclerites to the postnotum; a small velvety-black spot on the dorsal pteropleurite; pleurotergite dark brown, the elevated ventral portion densely set with golden-yellow tomentum. Halteres dusky, the base yellow, the knobs obscure yellow. Legs with the coxæ and trochanters yellow; femora yellow basally, passing into black on the distal half, this darkening enclosing a pale yellow subterminal ring; tibiæ with the extreme bases yellow, the remainder dark brown; tarsi dark reddish brown. Wings with the ground-color grayish brown, variegated with dark brown and cream-colored areas; prearcular region chiefly darkened, separated from a more extensive post-arcular area by clear yellow at arculus; no dark spots along cell *Sc*, as usual in the *glaphyroptera* group; stigma darkened; small dark areas along cord and at near mid-length of vein *Cu;* the chief creamy areas appear as a W-shaped mark lying transversely across cells *C*, *Sc*, *R* and *M* before the cord; the distal fourth of cell R_5; a narrow, irregular line beyond the stigma; small

marginal spots in outer ends of cells *2nd* M_2, M_3, M_4 and *1st* A, there being two in the last-named cell; and extensive area in basal half of cell *Cu*, extending into cell *M;* veins dark, pale in the creamy areas. Venation: R_{1+2} entire; R_{4+5} usually sinuous, deflected caudad on outer half, cell R_3 at margin being unusually wide.

Abdominal tergites chiefly blackened, the incisures of the basal segments more cinnamon-brown; outer segments margined laterally with cinnamon-brown; basal sternites reddish brown, segment four chiefly darkened; outer segments darkened, except at margins. Male hypopygium relatively large, the tergite fused with the sternite. Tergite with the median region produced into a depressed lobe, its apex with a shallow V-shaped notch; extreme margin narrowly chitinized and produced at lateral angles into small ventral spines; lateral region of tergite bearing a tuft of long yellow setæ. Region of basistyle not differentiated from sternite except by a short straight suture below; apex of basistyle truncated. What appears to be a curiously modified outer dististyle is borne at end of basistyle, appearing as a pale membranous lobe that is prolonged ventrad into a ribbon-like extension. Ninth sternite bearing two conspicuous subcylindrical lobes, closely applied to one another to appear almost as a single structure. Ovipositor with all valves well-developed, the tergal valves hairy except on distal third; sternal valves compressed, yellow.

HABITAT: Colombia. *Holotype*, ♂, Vista Nieve, Mt. Santa Marta, altitude about 5,000 feet, August 8, 1926 (F. W. Walker). *Allotopotype*, ♀, August 6, 1926. *Paratopotype*, a damaged ♂, August 7, 1926.

The general resemblance of this fly to various species of the *oblique-fasciata* group is probably superficial only. The species is well-distinguished by the peculiar structure of the male hypopygium.

Limonia Meigen.

Limonia (Rhipidia) tripectinata sp. n.

Belongs to the *maculata* group; allied to *inaequipectinata;* antennae (♂) elongate; flagellar segments 2 to 11 unequally tripectinate, there being a very small median spur, in addition to the elongate branches; wings with four darkened clouds in the subcostal field, in addition to the stigma; male hypopygium with the rostral prolongation of the ventral dististyle long and slender, with two spines that arise close together.

Male.—Length, about 6 mm.; wing, 7 mm.

Female.—Length, about 7.5-8 mm.; wing, 7.5.

Rostrum and palpi black. Antennæ (♂) very large and conspicuous, if bent backward extending to some distance beyond the base of

abdomen; scape black, the flagellar segments white, the basal swelling and all branches black; terminal segment entirely black; branches very long and slender, the longest approximately one-third the length of the entire organ; in addition to the long branches, there arises between them a small spur, forming a very unequal third branch; branch of first flagellar segment single; segments 2 to 11 unequally tripectinate, as described, the branches of outer segments gradually decreasing in length; terminal segment elongate, a trifle shorter than the branches of the penultimate segment. Antennæ (♀) nearly simple, the flagellar segments with very short, inconspicuous apical pedicels; terminal segment elongate. Head dark gray.

Pronotum black. Mesonotal praescutum reddish brown, the color broadened behind, the lateral and humeral regions extensively more yellowish; median region of praescutum narrowly darker brown; scutum reddish brown; scutellum darker brown, paler medially; postnotum dark brown. Pleura pale grayish brown, with two vague darker longitudinal stripes, the more dorsal stripe ending at the pteropleurite, the ventral stripe extending from the fore coxæ to the base of abdomen. Halteres pale yellow, the knobs weakly infuscated. Legs with the coxæ yellow, darkened basally; trochanters yellow; femora yellow, narrowly and vaguely darkened subapically; tibiæ brownish yellow; tarsi passing into darker brown. Wings with the ground-color creamy, with a restricted dark pattern, this consisting of four diffuse dark clouds in the subcostal field, in addition to the stigma; restricted pale brown seams along cord and outer end of cell *1st* M_2; wing-tip, especially in the outer ends of the radial cells, darkened; veins yellow, darker in the clouded areas. Venation: *Sc* long, Sc_1 ending about opposite two-thirds the length of *Rs*, Sc_2 at its tip; *Rs* gently arcuated at origin; free tip of Sc_2 and R_2 in approximate transverse alignment; *m-cu* at fork of *M*.

Abdominal segments obscure yellow, the caudal margins conspicuously ringed with dark brown; hypopygium obscure yellow. Male hypopygium with the tergite transverse, the caudal margin convex, the median region transverse or feebly concave. Basistyle moderately large, the ventro-mesal lobe stout basally, narrowed to an obtuse point that bears a single long powerful seta. Ventral dististyle of moderate size, a little larger than the basistyle; rostral prolongation long and slender, at about two-thirds the length bearing two long slender spines that are placed close together. Dorsal dististyle elongate, curved and narrowed to a long acute apical point. Gonapophysis with the mesal-apical lobe blackened, obliquely obtuse at tip, separated from the shorter outer lobe by a narrow U-shaped notch.

HABITAT: Colombia. *Holotype*, ♂, Vista Nieve, Mt. Santa Marta, altitude about 5,000 feet, August 7, 1926 (F. W. Walker). *Allotopotype*, ♀, August 7, 1926. *Paratopotypes*, 3 ♂♂, 10 ♀♀, August 6–8, 1926.

Limonia (*Rhipidia*) *tripectinata* has an antennal structure that is much like that of *L.* (*R.*) *inæquipectinata* Alexander, which differs conspicuously in the smaller antennae, the wing-pattern and venation, and in the structure of the male hypopygium.

Limonia (Rhipidia) mystica sp. n.

Belongs to the *uniseriata* group; general coloration yellow, the mesonotal praescutum with a broad, median brown stripe; antennae entirely black; flagellar segments 1 to 10 with a single branch; thoracic pleura yellow, with two narrow black stripes; halteres black; wings whitish, with a conspicuous brown and gray clouded pattern; cell M_2 tending to be open by atrophy of the basal section of M_3; male hypopygium with the spines of the rostral prolongation of the ventral dististyle short and spike-like.

Male.—Length, about 5 mm.; wing, 6 mm.

Rostrum and palpi black, the former about as long as the remainder of head. Antennæ black; basal flagellar segments with a single branch, the formula being 2+10+2; longest branch (about flagellar segments 7 to 9) approximately three times the segment; basal flagellar segment with a stout basal branch that is shorter than the segment; penultimate segment simple, or nearly so; terminal segment elongate, narrowed outwardly. Head black, sparsely pruinose.

Pronotum yellow, narrowly dark brown medially. Mesonotal praescutum buffy yellow, with a broad dark brown median stripe that is a trifle expanded laterally at near midlength; lateral stripes lacking or represented only by a small circular dusky cloud at the suture; scutum yellow, each lobe with a triangular brown area, the point directed caudad onto the scutellum; scutellum yellowish testaceous; postnotal mediotergite chiefly dark brown, pale yellow laterally. Pleura yellow, with two narrow black longitudinal stripes, the dorsal one extending from the cervical sclerites across the dorsal pleurites to the halteres; ventral stripe less distinct and more broken, including the dorsal sternopleurite and the meral region. Halteres short, black, the extreme base of the stem yellow, the knobs large. Legs with the coxæ yellow, slightly darkened across their bases; trochanters yellow; femora brownish yellow, vaguely darkened outwardly; tibiæ and tarsi pale brown, the terminal tarsal segments blackened; posterior legs lost. Wings whitish, more cream-colored in the costal region, with a heavy brown costal pattern and abundant gray clouds that cover most of the remainder of the wing; dark clouds six in number, the first two confluent or nearly so; fourth area at origin of *Rs;* fifth at fork of *Sc*, the sixth at stigma; the gray clouds include the cord and a more or less complete subapical fascia; medial, cubital and anal cells more evenly clouded with gray; the ground-color appears at the outer

end of cell *M*, bases of Anal cells and as a smaller area in cell *1st A* at end of vein *2nd A;* veins cream-yellow in the ground-areas, more infuscated elsewhere. Venation: Sc_1 ending about opposite three-fifths the length of *Rs*, Sc_2 at its tip; *Rs* long, gently arcuated; R_2 faint, subequal to the free tip of Sc_2; cell M_2 open or tending to be open by the atrophy of the basal section of M_3; *m-cu* close to fork of *M*. In one wing of the type, the basal section of M_3 is entirely atrophied; in the other wing, it is indicated by a vague trace.

Abdominal tergites yellowish brown, the caudal margins narrowly blackened; sternites more uniformly yellow; hypopygium brownish yellow. Male hypopygium with the tergite transverse, its caudal margin straight or very gently concave. Basistyle small, with a large ventro-mesal lobe. Ventral dististyle considerably larger than the basistyle, the rostral prolongation slender, with two small spike-like spines at near midlength, these placed close together. Dorsal dististyle a slightly curved darkened rod, slightly dilated outwardly, the tip suddenly narrowed to a slender point. Gonapophyses with the mesal apical lobe darkened, the outer margin roughened, the apex a more slender blackened point.

HABITAT: Colombia. *Holotype*, ♂, Vista Nieve, Mt. Santa Marta, altitude about 5,000 feet, August 7, 1926 (F. W. Walker).

The closest relative of the present species is *L.* (*R.*) *pallatangæ* Alexander (Ecuador), which differs in the larger size, details of coloration of the antennae, body and wings, and the much shorter flagellar branches.

Gynoplistia Westwood.

Gynoplistia (**Gynoplistia**) **variata** sp. n.

Generally similar and most nearly allied to *G.* (*G.*) *manicata* Alexander (Chile), differing most conspicuously in the smaller size and absence of blackened femoral tips.

Male.—Length, about 17-18 mm.; wing, 14.5-15 mm.

Antennæ (♂) 18-segmented, the formula being 2+2+8+6; scape and apices of flagellar segments yellow, the branches and basal enlargements of the segments darkened, the outer segments more uniformly darkened; longest branch (about flagellar segment 7 or 8) about five times the segment and shorter than the combined length of the simple terminal flagellar segments; last branch shorter than to approximately twice the length of the segment. Head brown.

Mesonotum brown, with a yellowish pollen, the praescutal stripes only feebly indicated. Pleura chiefly covered by a silvery-yellow bloom, the ventral sternopleurite more glabrous. Halteres pale, the knobs infuscated. Legs with the femora brownish yellow, the tips weakly darkened but not at all blackened, as in *manicata;* tibiæ yellow, the tips more narrowly darkened. Wings pale yellow, the stigma a

very little darker; in the holotype with a few grayish brown blotches in cells *M* and *Cu* near the cord and larger ones in the ends of the Anal cells, including a larger area in cell *1st A* that almost crosses the cell. Venation: Much as in *manicata*, with the anterior branch of *Rs* similarly long and sinuous; *Rs* a little shorter; cell *1st* M_2 slightly narrower, especially on the basal half.

Abdominal tergites grayish brown, the basal sternites bilineate with black; hypopygium yellowish brown. Male hypopygium with the outer dististyle much as in *manicata*. Interbases appearing as nearly simple chitinized horns, with a microscopic point on margin at near midlength.

HABITAT: Chile. *Holotype*, ♂, Angol, Malleco, November 25, 1929 (D. S. Bullock). *Paratopotype*, ♂, April 30, 1929.

Gynoplistia (Gynoplistia) biarmata sp. n.

Generally similar and allied to *G.* (*G.*) *manicata* Alexander, differing especially in the absence of black femoral tips and the structure of the male hypopygium, especially of the interbasal processes.

Male.—Length, about 23 mm.; wing, 19 mm.

Antennæ 19-segmented, the formula being 2+2+9+6; black, the incisures of the basal flagellar segment restrictedly yellow; tips of flagellar branches paler than their bases; longest branch shorter than the combined terminal simple segments; last branch about one-half longer than the segment; terminal segment constricted, as in the group. Head gray.

Mesonotum gray, the praescutum with three brown stripes, the median stripe darker in front, weakly divided behind; pseudosutural foveæ bicolorous, reddish with the lateral portion blackened; median region of scutum and the scutellum light gray; postnotal mediotergite yellowish brown, sparsely pruinose. Pleura heavily pruinose. Halteres pale yellow, the knobs weakly infuscated. Legs with the femora dark brown, yellow basally; tibiæ abruptly yellow, with narrowly darkened tips; tarsi yellow, the outer segments a little darkened. Wings pale yellow, the oval stigma pale brown; a small brown cloud at end of vein R_3; veins brown, more yellowish in the costal region. Venation as in *manicata* and allies.

Abdomen black, pruinose, the segments very narrowly margined laterally and caudally with yellow; hypopygium chiefly dark. Male hypopygium as in *manicata* and allies, but the interbasal processes very different in form, broad-based, with two large spines, the more basal larger and bearing a microscopic spinule on outer margin at near midlength.

HABITAT: Chile. *Holotype*, ♂, Angol, Malleco, 1928 (D. S. Bullock).

The two species described above, *Gynoplistia* (*Gynoplistia*) *variata* sp. n. and *G.* (*G.*) *biarmata* sp. n., together with *G.* (*G.*) *gilvipennis* Alexander and *G.* (*G.*) *manicata* Alexander, and very possibly also *G.* (*G.*) *flavipennis* (Philippi), form a compact group of large Gynoplistiæ in which the anterior branch of *Rs* is long and conspicuously sinuous and the tibial spurs and tarsal claws of both sexes are microscopically toothed.

Eriocera Macquart.

Eriocera tholopa sp. n.

General coloration black, heavily pruinose; antennae short in both sexes; head dull orange, darkened behind; mesonotal praescutum with three shiny black stripes, the lateral margins pruinose, the interspaces more yellowish pollinose; legs and halteres black; wings dusky, the cord seamed with darker; R_2 at or before the fork of R_{4+5}; cell M_1 lacking; *m-cu* at fork of *M;* ovipositor very long and slender.

Male.—Length, about 9 mm.; wing, 7 mm.

Female.—Length, about 12 mm.; wing, 8.5 mm.

Rostrum and palpi black. Antennæ black throughout, short in both sexes, 7-segmented (♂), 9-segmented (♀); first flagellar segment nearly as long as remainder of flagellum. Head dull orange, the occiput infuscated; vertical tubercle weakly bifid.

Mesonotal praescutum with three shiny black stripes, the lateral margins pruinose, the interspaces more yellowish pollinose; posterior sclerites of mesonotum black, sparsely pruinose, the scutellum and postnotum more heavily so. Pleura black, heavily pruinose, the dorso-pleural region slightly more buffy. Halteres black; the extreme base of stem paler. Legs with the coxæ pruinose; trochanters black; femora black, the extreme bases more reddish brown; tibiæ brownish black to black; tarsi black. Wings dusky, the costal region darker, the wing-base somewhat more yellowish brown; narrow darker brown seams along cord and veins *Rs* and R_5; veins black. Venation: Sc_1 ending opposite the fork of *Rs*, Sc_2 at its tip; *Rs* elongate, weakly angulated at origin; R_2 at or just before the fork of R_{3+4} (♂) or more than its own length before this fork (♀); cell M_1 lacking; *m-cu* at or beyond the fork of *M*, longer than the distal section of Cu_1.

Abdomen black, gray pruinose, more heavily so on the basal portions of the segments; male hypopygium black. Ovipositor with the tergal valves exceedingly long and slender, horn-yellow, blackened at bases.

HABITAT: Brazil. *Holotype*, ♂, Jaragua, Santa Catharina, October 10, 1929 (F. Schade). *Allotopotype*, ♀, October 9, 1929.

Eriocera tholopa is apparently closest to *E. flaviceps* (Wied.), differing in the coloration of the body and wings. The latter species is still known to me only from the very brief and insufficient original description.

Elephantomyia Osten Sacken.

Elephantomyia (Elephantomyia) humilis sp. n.

Size small (wing, not exceeding 6.5 mm.); thorax entirely yellow, immaculate; legs pale brown; wings yellowish subhyaline.

Male.—Length, excluding rostrum, about 5.5 mm.; wing, 5.8 mm.; rostrum, about 6 mm.

Female.—Length, excluding rostrum, about 6.5 mm.; wing, 6.5 mm.; rostrum, about 5 mm.

Rostrum elongate, subequal to or longer than the body, dark brown, including the palpi. Antennæ dark brown, the verticils very long and conspicuous, much exceeding the segments in both sexes. Head very light gray.

Thorax entirely yellow, unmarked. Halteres pale, the knobs weakly infuscated. Legs with the coxæ and trochanters yellow, the fore coxæ slightly infuscated on outer face; remainder of legs pale brown; a weak tibial spur on hind legs of male, not developed on other legs, at least of female. Wings yellowish subhyaline, a little darker toward apex; stigma long-oval, brown; veins brown, those of basal half of wing somewhat more yellowish brown. Venation: Sc_2 ending shortly before the fork of *Rs*, Sc_1 atrophied or nearly so; *Rs* long, gently arcuated to feebly angulated; branches of *Rs* long, extending generally parallel for their entire length; cell *1st* M_2 short-rectangular, shorter than any of the veins beyond it; *m-cu* subequal to or longer than the distal section of Cu_1, at or before midlength of cell *1st* M_2; cell *2nd A* long and narrow.

Abdomen yellowish brown, the sternites somewhat paler; in the female, the basal tergites are weakly bicolorous, the proximal half being somewhat darker than the remainder; on the outer segments the color is more uniform brown. Male hypopygium with the mesal face of the basistyle densely cushioned. Outer dististyle unusually short and stout, broad-based, shorter than the strongly curved inner dististyle.

HABITAT: Colombia. *Holotype*, ♂, Vista Nieve, Mt. Santa Marta, altitude about 5,000 feet, August 8, 1926, at light, 4 A. M. (F. W. Walker). *Allotopotype*, ♀, August 6, 1926. *Paratopotype*, ♂, with the allotype.

Elephantomyia humilis is even smaller than *E. boliviensis* Alexander, differing from the latter in the details of body-coloration and wing-venation, such as the straighter anterior

branch of *Rs*, small cell *1st* M_2 and more elongate vein *2nd A*. The paratype is very small and has lost the head, but seems undoubtedly to represent the same species.

Elephantomyia (Elephantomyia) angustissima sp. n.

General coloration yellow; pronotum and praescutum with a brown median stripe; femora obscure yellow, the tips narrowly blackened, preceded by a wide clearer yellow annulus; male hypopygium with the inner dististyle relatively elongate, a trifle longer than the outer style.

Male.—Length, excluding rostrum, about 8 mm.; wing, 8.5 mm.; rostrum, about 8 mm.

Female.—Length, excluding rostrum, about 9 mm.; wing, 8 mm.; rostrum, about 8 mm.

Rostrum nearly as long as the body in both sexes, dark brown. Antennæ with the scapal segments dark brown, the flagellum paler; flagellar segments becoming more slender and attenuate outwardly. Head yellowish gray, the center of the posterior vertex more infuscated; anterior vertex reduced to a strip that is a little narrower than the diameter of the first scapal segment.

Pronotum and mesonotum yellow, the anterior portion with a dark brown median stripe that becomes obsolete at near midlength of the praescutum. Pleura yellow. Halteres pale, the knobs weakly infuscated, the extreme base of the stem yellow. Legs with the coxæ and trochanters yellow; femora obscure yellow, the extreme tips blackened, preceded by a wider, more diffuse, clearer yellow ring; tibiæ and tarsi yellowish brown to pale brown; tibial spurs present. Wings with a yellowish tinge, the apex more darkened, cells *C* and *Sc* a little more suffused; stigma oval, dark brown; veins dark brown. Venation: Sc_1 ending about opposite the fork of *Rs*, Sc_2 at its tip; *Rs* relatively short, weakly angulated at origin; branches of *Rs* extending nearly parallel to one another for their entire length, the upper branch a little sinuous beneath the stigma; *m-cu* at near midlength of cell *1st* M_2, exceeding the distal section of Cu_1.

Abdominal tergites brownish yellow, with a more or less continuous brown median line, more expanded on the caudal margins of the segments; subterminal segments more uniformly darkened; sternites yellow, the caudal margins of the segments narrowly darkened. Male hypopygium with the mesal face of the basistyle with relatively few but long and conspicuous, erect setæ. Outer dististyle relatively elongate, bifid at apex. Inner dististyle only a trifle longer than the outer, nearly straight. Gonapophyses appearing as long, slender, sinuous spines. Aedeagus a penefilum of moderate length and stoutness.

HABITAT: Colombia. *Holotype*, ♂, Vista Nieve, Mt. Santa Marta, altitude 5,000 feet, August 6, 1926 (F. W. Walker). *Allotopotype*, ♀.

Elephantomyia angustissima is distinct from all described regional species in the pattern of the legs and structure of the male hypopygium. It is closest to *E. westwoodi* O. S. of the Nearctic fauna, differing especially in the details of structure of the hypopygium, especially of the gonapophyses.

Teucholabis Osten Sacken.

Teucholabis (Teucholabis) marticola sp. n.

General coloration black; mesonotal praescutum yellow, with three nearly confluent blackish stripes; scutellum yellow; knobs of halteres infuscated; femora yellow, the tips blackened; wings subhyaline, the small stigma pale brown; male hypopygium with the apical spine of the basistyle very reduced; outer dististyle simple, terminating in an acute blackened spine.

Male.—Length, about 4.5 mm.; wing, 4 mm.

Rostrum black, nearly as long as the remainder of head; palpi black. Antennæ black throughout; flagellar segments oval, decreasing in size outwardly. Head black, sparsely pruinose.

Pronotum obscure yellow, narrowly blackened laterally. Mesonotal praescutum shiny yellow, the disk chiefly covered by three blackish brown stripes that are nearly confluent, the median stripe paler than the laterals; scutal lobes blackened, the median region obscure yellow; scutellum pale yellow; postnotal mediotergite dark reddish brown. Pleura chiefly black, the ventral sternopleurite and meral region more reddish. Halteres pale, the knobs infuscated. Legs with the coxæ reddish brown, the trochanters more yellowish; femora yellow, the tips broadly blackened, the amount nearly equal on all legs; tibiæ yellowish brown, darker apically; tarsi broken. Wings subhyaline, the small, subcircular stigma pale brown; veins pale brown. Venation: Sc_1 ending about opposite one-third the length of the long arcuated Rs, Sc_2 opposite the origin of the latter; R_2 lying just beyond the level of the basal section of R_5; R_{1+2} short, the tip subobsolete; cell *1st* M_2 long, widened outwardly, *m* longer and more arcuated than the basal section of M_3.

Abdominal tergites dark brown, the caudal margins of the segments narrowly pale; sternites more uniformly pale; hypopygium yellowish. Sternal pocket relatively simple. Male hypopygium with the basistyle short, the apical spine very tiny. Outer dististyle a simple slender rod that narrows to a slender smooth blackened spine. Inner dististyle small, very strongly curved, the tip blackened, narrowed to a slightly decurved point.

HABITAT: Colombia. *Holotype*, ♂, Mt. Santa Marta, November 1, 1926, at light (G. Salt).

By means of my key to the American species of *Teucholabis* (Trans. Amer. Ent. Soc., 40: 235–239; 1914), *Teucholabis*

marticola runs to couplet 24, disagreeing with both included species, *tristis* Alexander (Peru) and *molesta* Osten Sacken (Mexico), in the coloration of the thoracic dorsum, infuscated halteres, and details of venation.

Gonomyia Meigen.

Gonomyia (Lipophleps) lemniscata sp. n.

Belongs to the *pleuralis* group; size small (wing, ♂, 3.5 mm.); male hypopygium with the dististyle terminating in a short blackened spine; on outer face of style at near mid-length with a small spike-like spine that is surrounded by numerous erect setae.

Male—Length about 3 mm.; wing, 3.5 mm.

Rostrum and palpi black. Antennæ with the scape and basal segments of the flagellum orange-yellow, the remainder of the flagellum brown. Head chiefly pale yellow.

Pronotum and anterior lateral pretergites whitish. Mesonotal praescutum fulvous-brown; scutal lobes similarly colored; median region of scutum and the scutellum more yellowish, with a continuous capillary brown median line; postnotum yellow. Pleura yellow, with two narrow brown longitudinal stripes. Halteres pale, the knobs weakly darkened. Legs with the fore coxæ darkened, the remaining coxæ yellow; trochanters yellow; femora light brown, darkening to a narrow subterminal ring, the extreme apex again pale; tibiæ and tarsi pale brown. Wings with a faint brown tinge, the base and costal region clear yellow; stigma oval, dark brown, as in the group; cells on either side of the cord variegated by pale creamy areas; veins pale, the cord and outer end of cell *1st* M_2 darker. Venation: Sc_1 ending a short distance before the origin of *Rs*, the distance on Costa being a little more than one-half of *Rs*; anterior branch of sector pale, strongly curved cephalad around the stigma; veins R_5 and M_{1+2} approximated at wing-margin.

Abdominal tergites pale yellow medially, margined caudally and laterally with brown; sternites more uniformly pale, margined caudally with brown. Male hypopygium of the general structure of *recurvata*, differing especially in details of the dististyle. Outer fleshy lobe of basistyle relatively stout; spinous lobe of basistyle pale basally, narrowed to an acute point. Dististyle extended into a short, blackened spine, immediately before this with a small fleshy lobe bearing two fasciculate setæ; outer face of style at near midlength bearing a small spike-like spine that is surrounded by numerous erect setæ. Gonapophyses of both sets almost as in *recurvata*, the elongate arms delicately fringed with setæ along mesal edge; apical lobes of median phallosomic structure pale, elongate, gently divergent.

HABITAT: Colombia, Brazil. *Holotype*, ♂, Vista Nieve, Mt. Santa Marta, Colombia, altitude 5,000 feet, August 8, 1926, at light, 4 A. M. (F. W. Walker). *Paratype*, ♂, Jaragua, Santa Catharina, Brazil, September 20, 1929 (F. Schade).

Gonomyia (*Lipophleps*) *lemniscata* is allied to *G.* (*L.*) *recurvata* Alexander, differing in the details of structure of the male hypopygium, more especially of the dististyle. The occurrence of this species and *Limonia* (*Geranomyia*) *walkeri* Alexander on Mt. Santa Marta and again in Santa Catharina in southeastern Brazil is worthy of note.

Gonomyia (Gonomyia) methodica sp. n.

Belongs to the *subcinerea* group; general coloration dark brown; antennae black throughout; scutellum light yellow; pleura yellow, the anepisternum more darkened; wings tinged with brown; *Sc* short, Sc_1 ending opposite origin of *Rs*, Sc_2 at its tip; R_3 gently arcuated, not deflected cephalad at outer end; male hypopygium with the outer dististyle a small oval fleshy lobe; phallosome bearing two strongly hooked lateral spines.

Male.—Length about 4.4 mm.; wing, 5.2 mm.

Rostrum and palpi black. Antennæ black throughout; outer flagellar segments becoming long and slender, with relatively long dense verticils. Head dark gray.

Pronotum dark brown. Mesonotal praescutum and scutal lobes dark brown, very sparsely pruinose; anterior lateral pretergites and restricted humeral region very pale yellow; pseudosutural foveæ elongate, black; median region of scutum testaceous-yellow; scutellum light yellow, the base medially with a darkened spot; postnotal mediotergite pale brown, sparsely pruinose, the cephalic-lateral portions restrictedly yellow. Posterior pleura and pleurotergite pale yellow, without clearly defined dark markings, the cephalic pleurites weakly infuscated. Halteres dusky, the extreme base of the stem pale yellow. Legs with the coxæ pale yellow, the fore coxæ slightly more darkened; trochanters pale yellow; remainder of legs dark brown. Wings with a brown tinge, the ill-defined stigma slightly darker brown; veins dark brown. Costal fringe relatively long and conspicuous. Venation: *Sc* short, Sc_1 ending just beyond the origin of *Rs*, Sc_1 subequal to Sc_2; *Rs* relatively short, less than R_{2+3+4}; R_3 gently arcuated, not deflected cephalad at tip, as in allied species; *m-cu* at two-fifths the length of cell *1st* M_2.

Abdominal tergites dark brown, the sternites pale; hypopygium yellowish brown. Male hypopygium with the basistyle relatively short and stout, the outer lateral lobe longer than either dististyle; a small blunt tuberculate lobe on mesal face of proximal end of basistyle. Outer dististyle a small, oval, fleshy lobe that is densely covered with delicate setulæ and a few long setæ. Inner dististyle a little larger,

produced into a gently curved blackened spine, the margin of which, at near midlength, bears a long seta; apex of style a short blunt lobe bearing several setæ, two of which are larger and fasciculate. Phallosome asymmetrical, large and complex, bearing at near midlength a pale oval lobe; two lateral spines that are strongly interlocked.

HABITAT: Colombia. *Holotype*, ♂, Vista Nieve, Mt. Santa Marta, altitude about 5,000 feet, August 7, 1926 (F. W. Walker).

Gonomyia (*Gonomyia*) *methodica* is readily distinguished from allied regional species by the structure of the male hypopygium.

Neognophomyia Alexander.

Neognophomyia colombicola sp. n.

General coloration of mesonotal praescutum reddish; postnotum blackened; pleura pale yellow, with a conspicuous blackened dorso-longitudinal stripe; wings whitish, with a relatively narrow brown seam along cord; cell *1st* M_2 strongly widened outwardly; male hypopygium with the lateral tergal spines blackened, microscopically setulose before the acute tips.

Male.—Length, about 6-6.5 mm.; wing, 6-6.5 mm.

Female.—Length, about 6.5-7 mm.; wing, 6-6.5 mm.

Rostrum yellow; palpi more darkened, especially the outer segments. Antennæ brownish black; flagellar segments oval, more elongate-oval in male. Head yellow; vertex relatively narrow.

Anterior lateral pretergites yellowish white. Mesonotal praescutum pale reddish or reddish brown, in cases with vague indications of darker stripes; scutal lobes dark brown or brownish black, the median region paler, more silvery; scutellum pale; postnotal mediotergite chiefly blackened, the lateral and cephalic portions narrowly pale. Pleura pale yellow, with a more or less entire, black, dorso-longitudinal stripe, beginning on the propleura, extending to the postnotal mediotergite, best defined as two large areas on the anepisternum and pleurotergite, more nearly interrupted on the dorsal pteropleurite. Halteres pale. Legs with the coxæ and trochanters yellow; femora yellow, the tips more or less infuscated; remainder of legs yellow, the outer tarsal segments passing into brown. Wings whitish, with a relatively narrow brown seam along the cord, narrowed behind, subobsolete on *m-cu;* a scarcely indicated dark seam on outer end of cell *1st* M_2; vague darkenings across the basal cells; veins brown, darker in the infuscated areas. Venation: Sc_1 ending opposite or just beyond R_2, Sc_2 pale, beyond midlength of Rs; R_2 about one-half R_{3+4}; cell *1st* M_2 strongly widened outwardly; a weak angulation or spur on m near its union with M_3; cell *2nd* A relatively wide.

Abdominal tergites dark brown, the basal segments yellow medially; sternites more uniformly pale yellow. Male hypopygium with the tergal spines appearing as blackened, gently curved rods that narrow

gradually to acute points, before their apices fringed with delicate setulæ.

HABITAT: Colombia. *Holotype*, ♂, Vista Nieve, Mt. Santa Marta, altitude about 5,000 feet, August 8, 1926 (F. W. Walker). *Allotopotype*, ♀, August 8, 1926, at light, 4 A. M.; *Paratopotypes*, 5 ♂ ♀, August 6–8, 1926.

The most nearly allied species seems to be *N. pervicax* (Alexander) of Peru, which differs in the venation and structure of the male hypopygium, especially the tergal spines.

Gnophomyia Osten Sacken.

Gnophomyia acricula sp. n.

General coloration of mesonotum black; thoracic pleura striped longitudinally with dark and pale; halteres with darkened knobs; legs obscure yellow; wings with a weak brown tinge; *r-m* connecting with *Rs* shortly before the fork; male hypopygium with the outer dististyle a simple, gently curved rod that gradually narrows to a subacute blackened apex.

Male.—Length, about 7 mm.; wing, 6 mm.

Female.—Length, about 7 mm.; wing, 6 mm.

Rostrum and palpi black, paler in the female. Antennæ black throughout; flagellar segments long-oval, with verticils that are subequal to or a little longer than the segments. Head brown; eyes of female apparently larger than in male, approximated or contiguous on the vertex, in the male separated by a strip of moderate width.

Pronotum brownish black. Anterior lateral pretergites restrictedly pale yellow. Mesonotal praescutum black or brownish black, sparsely pruinose; humeral and lateral regions restrictedly brightened; posterior sclerites of mesonotum blackened. Pleura variegated, the dorsal pleurites with a black longitudinal stripe, most intense on the anepisternum; beneath this stripe on the dorsal sternopleurite a more yellowish area; ventral sternopleurite brown, more or less pruinose. Halteres dark brown or brownish black, the extreme base of stem brightened. Legs with the coxæ and trochanters yellow, the large posterior coxæ, together with the meral region, more conspicuously so; trochanters yellow; remainder of legs obscure yellow, the outer tarsal segments darkened. Wings with a weak brownish suffusion, the stigma scarcely indicated; veins dark brown. Venation: Sc_1 ending just before the subevanescent R_2, Sc_2 opposite *r-m*; *r-m* connecting with *Rs* a short distance before the fork of the latter; *m-cu* opposite *r-m* and a short distance beyond the fork of *M*.

Abdominal tergites blackened; sternites more yellowish; hypopygium dark. In the female, the incisures are slightly darkened. Male hypopygium with the basistyles short and stout. Outer dististyle a simple, gently curved rod, gradually narrowed to the subacute blackened

tip. Inner dististyle with the basal portion expanded, the apical extension obtuse, the whole style with several coarse setæ. What appears to be a tergal structure is a quadrate median plate, the apex decurved into two blunt blackened lobes that are separated by a small notch. Ovipositor with the valves blunt at tips, conspicuously hairy, the sternal valves very short.

HABITAT: Colombia. *Holotype*, ♂, Vista Nieve, Mt. Santa Marta, altitude about 5,000 feet, August 8, 1926, at light, 4 A. M. (F. W. Walker). *Allotopotype*, ♀, August 8, 1926.

Gnophomyia acricula is allied to *G. subhyalina* Alexander, differing especially in the body-coloration, details of venation, and structure of the male hypopygium.

Gnophomyia vilis sp. n.

General coloration pale reddish brown; pleura with a broken blackish longitudinal stripe; femora yellow, the tips weakly infuscated; wings tinged with grayish yellow, the veins yellowish brown; veins R_3 and R_4 long, extending nearly parallel for their entire length; male hypopygium with the outer dististyle a flattened blade, the apex obtuse; ovipositor with the tergal valves short and stout, truncated and setiferous at apex.

Male.—Length, about 6-7 mm.; wing, 5.5-6 mm.

Female.—Length, about 7-7.5 mm.; wing, 6-6.5 mm.

Rostrum pale brown; palpi darker brown. Antennæ brownish yellow, the outer flagellar segments somewhat darker; flagellar segments oval, becoming more slender outwardly, the verticils exceeding the segments. Head obscure yellow, in cases dark grayish brown.

Mesonotum reddish brown, the humeral region and anterior lateral pretergites more yellowish; median area of scutum more yellowish; scutellum more testaceous. Pleura reddish brown, with a conspicuous blackish dorsal stripe, most intense on the anepisternum, paler to subobsolete on the dorsal pteropleurite. Halteres brownish yellow, the knobs infuscated. Legs with the coxæ and trochanters yellow; femora and tibiæ yellow, the tips weakly infuscated; tarsi yellow, the outer segments passing into dark brown. Wings tinged with grayish yellow; veins light yellowish brown. Venation: Sc_1 ending just before R_2, Sc_2 some distance from its tip; R_2 a little shorter than R_{2+3}; veins R_3 and R_4 long, running nearly parallel for their entire length; *m-cu* at from one-third to two-fifths the length of cell *1st* M_2.

Abdominal tergites yellowish brown, darker laterally; sternites more uniformly yellow; hypopygium reddish yellow. Male hypopygium with the outer dististyle a flattened blade, gently arcuated, the apex broadly rounded. Inner dististyle short and stout, blackened, provided with small black setæ, the tip obtuse. Ovipositor with the valves unusually short and stout, the tergal valves truncated at tips, darkened, and bearing a few setæ.

HABITAT: Colombia. *Holotype*, ♂, Orihueca, November 13, 1925 (F. W. Walker). *Allotopotype*, ♀. *Paratopotypes*, 16 ♂ ♀.

Gnophomyia vilis is closest to *G. subhyalina* Alexander, differing in the coloration and venation of the wings and in the structure of the male hypopygium, especially the outer dististyle.

Molophilus Curtis.

Molophilus flexilistylus sp. n.

Belongs to the *plagiatus* group; antennae short; mesonotal praescutum reddish brown, with three more yellowish stripes; knobs of halteres infuscated; male hypopygium with the basal dististyle a long slender rod, expanded at apex, the margin at this point with a series of appressed spines, together with a single larger spine borne on the opposite margin.

Male.—Length, about 3.3-3.5 mm.; wing, 4-4.2 mm.

Female.—Length, about 3.5 mm.; wing, 4 mm.

Rostrum and palpi dark brown. Antennæ short in both sexes, if bent backward not attaining the wing-root, dark brown throughout. Head dark gray.

Mesonotal praescutum with the ground-color reddish brown with three more yellowish stripes; humeral region and anterior lateral pretergites obscure yellow; scutum and scutellum reddish brown, the latter somewhat more testaceous; postnotum brown. Pleura testaceous, the dorsal sclerites more infuscated. Halteres dusky, the knobs infuscated, the color in large part due to abundant dark setæ. Legs with the coxæ and trochanters testaceous; femora and tibiæ brownish yellow; tarsi a little darker. Wings with a brownish tinge, the prearcular and costal regions a little more yellowish; veins pale brown, the macrotrichia dark brown. Venation: Petiole of cell M_3 about one-half longer than *m-cu;* vein *2nd A* relatively short, ending opposite or just before the caudal end of the oblique *m-cu*.

Abdomen brown, including the hypopygium, the lateral region somewhat darker brown. Male hypopygium with the apical beak of the basistyle slender, gently curved. Basal dististyle a long, slender rod, dilated at apex and here with a lateral series of acute appressed spines, these decreasing in size outwardly; on opposite face, at base of expanded portion of style, with a longer appressed spine. Ovipositor with the valves long and slender, the tergal valves only gently curved.

HABITAT: Colombia. *Holotype*, ♂, La Cumbre, Mt. Santa Marta, altitude 8,000 feet, in deep cloud forest, August 8, 1926 (F. W. Walker). *Allotopotype*, ♀. *Paratopotypes*, 3 ♂ ♂, altitude 7,200–8,000 feet.

The diagnostic features listed above, especially the structure of the male hypopygium, are distinctive of the species. One paratype has the knobs of the halteres much paler, due to depilation.

Molophilus subtenebricosus sp. n.

Belongs to the *plagiatus* group; allied to *M. tenebricosus* Alexander (Colombia: Andes Occidental), differing especially in the structure of the male hypopygium.

Male.—Length, about 4.3 mm.; wing, 5.2 mm.

Antennæ elongate, strongly nodulose. General coloration of mesonotal praescutum blackish gray, with three reddish brown stripes; humeral and anterior lateral pretergites whitish; posterior sclerites of mesonotum, together with the pleura, blackish brown. Halteres pale. Male hypopygium with the apical beak of the basistyle slender, as in *tenebricosus*, but strongly curved. Basal dististyle a long slender rod, the base constricted, beyond this point flattened, with more than the apical third a slender, entirely smooth, black spine; outer aspect of dilated portion of style with abundant appressed setulæ.

HABITAT: Colombia. *Holotype*, ♂, Vista Nieve, Mt. Santa Marta, altitude about 5,000 feet, August 7, 1926 (F. W. Walker).

Molophilus walkeri sp. n.

Belongs to the *plagiatus* group; general coloration brownish gray; halteres yellow; wings obscure whitish, with two vague darker crossbands, one at the cord, the other in the basal cells; male hypopygium with the basal dististyle a powerful blackened rod, the distal two-thirds roughened with spinulae and spinous setae, the tip suddenly narrowed into a blackened spine, at near one-third the length on outer margin with a powerful erect spine.

Male.—Length, about 3.6-3.8 mm.; wing, 4.5-4.7 mm.

Rostrum and palpi black. Antennæ of moderate length, if bent backward extending about to the wing-root, black throughout; flagellar segments oval, gradually decreasing in size outwardly; verticils of basal segments long and conspicuous, becoming shorter and less conspicuous on the outer segments, on the penultimate being scarcely as long as the segment. Head black, sparsely pruinose.

Mesonotum dark brownish gray. Anterior lateral pretergites restrictedly pale yellow. Pleura black, sparsely pruinose. Halteres yellow. Legs with the coxæ black; trochanters brown; remainder of legs black, the femoral bases restrictedly pale. Wings obscure whitish, with two vague darker crossbands, one at the cord, the second more diffuse, crossing the basal cells; veins pale, somewhat darker in the infuscated areas; trichia of veins pale brown, darker and forming

conspicuous patches on those veins traversing the infuscated areas, especially along the cord. Venation: *m-cu* oblique, subequal in length to the petiole of cell M_3; vein *2nd A* ending shortly beyond the caudal end of *m-cu*.

Abdomen brownish black, including the hypopygium. Male hypopygium with the apical beak of the basistyle decurved to an acute point. Outer dististyle relatively slender, bifid at apex. Basal dististyle a powerful blackened rod, the apex narrowed into a blackened spine, the distal two-thirds of the style with abundant appressed spinulæ on all faces, those of the ventral or inner face more slender and spinous; on outer margin of style at near one-third the length with a powerful erect spine.

HABITAT: Colombia. *Holotype*, ♂, Vista Nieve, Mt. Santa Marta, altitude 5,000 feet, August 8, 1926, at light, 4 A. M. (F. W. Walker).

Molophilus walkeri is respectfully dedicated to the collector of this abundant series of Tipulidæ from Santa Marta, Mr. Fred W. Walker. The structure of the male hypopygium is distinctive.

Molophilus marthæ sp. n.

Belongs to the *plagiatus* group; general coloration of mesonotal praescutum reddish brown, the postnotum and pleura blackened; antennae relatively long, extending to beyond the wing-root; knobs of halteres infuscated; legs dark brown; wings tinged with brown, the long abundant macrotrichia dark brown; male hypopygium with the basal dististyle a powerful rod, the distal half fringed with setae and appressed spines; basal half of style on outer face with two powerful erect spines.

Male.—Length, about 3.5 mm.; wing, 4.4 mm.

Rostrum and palpi black. Antennæ black, relatively long, if bent backward extending to beyond the wing-root; flagellar segments oval, with long, unilaterally arranged verticils and additional long delicate setulæ. Head dark brown.

Mesonotal praescutum reddish brown, the anterior lateral pretergites whitish; scutal lobes and scutellum darker, the postnotum blackened. Pleura blackened. Halteres yellow, the knobs infuscated. Legs with the coxæ and trochanters yellow to testaceous yellow; remainder of legs dark brown. Wings with a faint brown tinge, more evident as a seam along vein *Cu;* veins pale brown, the long abundant macrotrichia dark brown; costal fringe long and dense. Venation: *m-cu* about two-thirds the length of the petiole of cell M_3; vein *2nd A* long, gently sinuous, ending beyond midlength of the petiole of cell M_3.

Abdomen brownish black, the hypopygium more yellowish. Male hypopygium with the apical beak of basistyle slender and straight; margin of basistyle cephalad of beak extensively blackened and

microscopically roughened. Outer dististyle relatively stout, bifid, the inner arm more elongate. Basal dististyle a powerful rod, the distal half or slightly less narrowed to a gently curved spine, the concave face provided with a dense fringe of setæ in addition to a series of appressed spines; basal half of style more enlarged, with two powerful erect spines. Phallosomic structure small, oval, glabrous.

HABITAT: Colombia. *Holotype*, ♂, Vista Nieve, Mt. Santa Marta, altitude about 5,000 feet, August 6, 1926 (F. W. Walker).

Molophilus marthæ is very distinct from all described species of the genus in the structure of the male hypopygium.

Molophilus bidigitatus sp. n.

Belongs to the *plagiatus* group; general coloration reddish brown, the head, pronotum and humeral regions of praescutum light yellow; thoracic pleura dark brown; halteres yellow; wings grayish yellow, the costal region clearer yellow; male hypopygium with the basal dististyle bifurcate at apex; phallosomic structure a pale setiferous cushion, its caudal end bifid.

Male.—Length, about 2.5 mm.; wing, 3.3 mm.

Rostrum and palpi brown. Antennæ with the scape yellow, the flagellum broken. Head pale yellow, more infuscated behind.

Pronotum and anterior lateral pretergites light sulphur-yellow. Mesonotum reddish brown, the humeral region of praescutum light sulphur-yellow; posterior sclerites of mesonotum somewhat darker brown. Pleura dark brown, the dorso-pleural region chiefly darkened, the posterior portion yellow. Halteres yellow, with golden setæ. Legs with the fore coxæ infuscated, the remaining coxæ and all trochanters yellow; remainder of legs broken. Wings grayish yellow, the base and costal region clearer yellow; veins pale, the macrotrichia brown. Venation: *m-cu* about two-thirds the petiole of cell M_3; vein *2nd A* relatively elongate, extending to about opposite one-third the length of the petiole of cell M_3.

Abdomen yellowish brown, darker laterally; hypopygium yellow. Male hypopygium with the apical beak of basistyle slender, gently curved. Outer dististyle bifid, the inner arm more slender. Basal dististyle having much the same shape as the apex of the outer dististyle, being conspicuously bifurcate, both arms appearing as slender blackened spines, the outer arm more curved and a little stouter than the inner spine; stem short. Phallosomic structure a pale cushion that is covered with long conspicuous setæ, the apex deeply notched medially. Aedeagus relatively short, subequal in length to the outer dististyle.

HABITAT: Brazil. *Holotype*, ♂, Jaragua, Santa Catharina, August 21, 1929 (F. Schade).

Molophilus bidigitatus is very distinct from all described Neotropical species in the structure of the basal dististyle of the male hypopygium.

A REVISION OF THE MALES OF THE NEARCTIC SPECIES IN THE GENUS FABRICIELLA (TACHINIDÆ)*

JOHN ALLEN ROWE.

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INTRODUCTION.

In 1924 J. D. Tothill revised the nearctic species in the genus *Fabriciella*, a name proposed by Bezzi in 1906 to replace *Fabricia* Rob. D. which is preoccupied. All species having the genital forceps agreeing with that of the genotype, *F. ferox* Panz, were included. Twenty-five species were included in the revision, eighteen of which were new. The species were separated on the basis of the genitalia of the males, but the descriptions and key are so inadequate that recognition of the species from this treatise is very difficult.

In this paper an attempt has been made to furnish for the males of the known nearctic species, including three here described as new, a treatment by which they may be definitely recognized. All species have been compared with types and paratypes now in the national collections. The descriptions emphasize genital differences, and figures of the male genitalia of all species are included.

*Contribution from the Zoological Laboratories of the University of Utah, Salt Lake City, Utah. No. 55.

At this time opportunity presents itself to acknowledge my indebtedness to those who have aided in the preparation of this paper. To Dr. J. M. Aldrich, U. S. National Museum, and C. H. Curran, American Museum Nat. History, I wish to express sincere appreciation for the loan of material, checking of species, and many valuable notes pertaining to this problem. To Dr. J. McDunnough of the Canadian National Museum, I wish to express sincere thanks for the new species described, and for figures of the genitalia of *F. longiunguis* Tot., *F. nivalis* Tot., and *F. canadensis* Tot. The work was completed under the supervision of Dr. Ralph V. Chamberlin, head of the Department of Zoology, at the University of Utah, whose kindly suggestions and valuable assistance were indispensable. Finally to my associates and fellow workers whose interests and encouragements have been most generous, I wish to express sincere thanks.

GENERIC CHARACTERISTICS.

The genus Fabriciella comprises those flies of the family Tachinidæ which have the following characteristics. Length ranging from 8–16 mm. Body robust and in most cases heavily bristled. Wings well developed and often tinged with orange near the base. Legs in all cases robust, with well developed pulvilli and claws.

Head as wide at the vibrissae as at the base of the antennae. Vibrissae situated far above the oral margin. Labial palpi well developed, yellow, bristled, and in most cases thickened on the distal end. Eyes not hairy. Genae pollinose, in many cases bearing black hairs. Frontal row well developed, and extending well below the base of the antennae. Ocellars present and directed forward. Post-ocular region densely covered with long white, golden, or yellow pile. Oculars directed backward. Facial depression usually shallow, pollinose and without median carina. Second segment of the antennae longer than the third. Arista usually thickened on the basal three-fourths.

Thorax dark and polished. Sternopleurals three. Dorsocentrals four. Scutellum with three to five marginals. (The number of bristles of the thorax is variable.) Post-scutellum prominent, pollinose. Squamae large, yellowish or white. Wings of the general Tachinid type with a few small bristles at the base of the third vein. Legs robust, heavily bristled. Claws and pulvillae well developed.

Abdomen black or orange with black mid-dorsal stripe. Second and third tergites with or without discal bristles and with well developed marginal bristles. Apex of abdomen heavily bristled.

Male genitalia usually very prominent. Forceps either greatly arched or flat. Processes of the accessory plates usually curved tusk-like, giving the appearance of a ring. Fifth sternite cleft, the cleft taking varied appearances, usually V-shaped or U-shaped.

CHARACTERS OF THE GENITALIA.*

Workers in all fields are beginning to pay more and more attention to the specific differences in the genitalia as a basis for the separation of species. This is due to the fact that in many cases the general morphology, size, and color have been found to be quite variable while the differences between species presented in the genital organs are constant.

The genitalia of the flies belonging to the genus Fabriciella comprise the abdominal segments beyond the fourth tergite and the fifth sternite. They are arranged successively, some being modified into organs specialized for copulation. The first genital segment (G. Plate I, Figure 1) is situated just beyond the fourth tergite. It serves as a base for the attachment of the following parts. Adjacent caudally to the first genital segment is the second genital segment (G2. Plate I, Figure 1) which bears the forceps, accessory plates and anal area. It is the largest of the genital segments and usually the most conspicuous. It is often specialized on the ventral margin, as in the case of *F. algens* Wd., and *F. latiannulum* Tot., into laterally projecting flaps and in one case, *F. spinosa* Tot., bears a group of short spines. These specializations serve excellently in separating the species. Caudad of and attached to the second genital segment are the accessory plates (AP. Plate I, Figure 1). These plates are also important as specific characters, some being prominent and some being completely hidden in lateral view by the forceps and second genital segment. They are modified on the lower end into characteristic tusk-like processes (PAP. Plate I, Figure 1) which extend ventrally and curve toward each other in the form of a ring. They serve as probers and claspers in the copulatory process. The forceps (F. Plate I, Figure 1) is the most posterior segment of the genitalia. Its size and shape is characteristic of the species; for this reason it is the most important morphological structure used in the classification of this group. In regard to its various sizes and shapes the reader is referred to the figures on the accompanying plates. Dorsally, between the forceps and the second genital segment the anal area (AA. Plate I, Figure 1)

*As indicated by the title and in the introduction this paper deals with males and male genitalia only. Accordingly the key given in this paper cannot be used for females.

is located. It is easily recognized because it is membraneous in character. It has various shapes, the most common being oblong, oval, and cordate. In many cases the anterior end is acutely angled.

Seated in a depressed ventral area between the latero-ventral margins of the second genital segment are the two pairs of claspers, the penis, and the genital sternum. In this area, projecting inward between the sides of the second genital segment is a chitinized plate which is held in place by membrane. This is the genital sternum (GS. Plate I, Figure 1) and serves as a base of attachment for the claspers and penis. Situated posteriorly on the sternum are the posterior claspers (PC. Plate I, Figure 1). They are small chitinized rods, blunt and somewhat enlarged on the end, either straight or gently curved, seated side by side and projecting over the penis. Anterior to the posterior claspers and originating under them are the anterior claspers (AC. Plate I, Figure 1). They are chitinized, usually larger than the posterior claspers, produced ventrally a short distance and then bent anteriorly thus appearing in the shape of a right angle. Both pair of claspers are used in clasping the female in copulation. The penis (P. Plate I, Figure 1) is usually well concealed by the anterior claspers and only a part of it can be seen without making a dissection. It is made up of a posterior chitinized part which at the distal end forms a ring, and a membraneous distal part which projects from the ring in the form of a hollow tube.

Another structure may be mentioned here because of its specialization and close proximity to the genitalia. The fifth sternite (5St, Plate I, Figure 1) is quite characteristic because of its variously shaped cleft (C5St, Plate I, Figure 1) and processes (P5St, Plate I, Figure 1). This structure is used often as an important character in classification.

The nomenclature used in the description of the genitalia as well as in the general description of species is essentially that used by Dr. J. M. Aldrich in his well known treatise, "Sarcophaga and Allies," Vol. I, Thomas Say Foundation.

KEY TO SPECIES.

1. Abdomen with conspicuous orange colored markings.
2. Dorsal surface of forceps flattened, or at least not strongly arched.
3. Second genital segment truncate ventrally, beak or forcep abruptly acuminate. Plate I, Figure 1.....**acuminata** Tot.
*3. Second genital segment not truncate. Parafrontals shining.
4. Ventral surfaces of the second genital segment with no large bristles.
5. Second genital segment inflated dorsally, forceps caudally appearing heart-shaped. Plate I, Figure 2.....**cordiforceps** n. sp.
*5. Second genital segment not so, beak with medium long, sharp tip. Plate I, Figure 3.....**florum** Wlk.
*4. Ventral surfaces of the second genital segment with large bristles.
6. Beak of forceps narrow, bristles only on extreme ventral surface. Plate I, Figure 4.....**spinosa** Tot.
*6. Beak of forceps very wide with the tip turned under. Plate I, Figure 5.....**lutzi** Curr.
*2. Dorsal surface of forceps distinctly arched.
7. Beak of forceps with very small tip.
8. Beak of forceps as broad as long, last segment of tarsus silvery pollinose. Plate I, Figure 6.....**argentia** n. sp.
*8. Beak of forceps not as broad as long.
9. Lateral ridges of beak ovately converging to a small tip. Plate I, Figure 7.....**longiunguis** Tot.
*9. Lateral ridges of beak parallel.
10. Cleft of fifth sternite V-shaped. A very pilose species. Plate II, Figure 8.....**pilosa** Tot.
*10. Cleft of fifth sternite narrowing above, parallel sides of beak long. Plate II, Figure 9.....**montana** Tns.
*7. Beak of forceps blunt or nearly so.
11. Beak of forceps very narrow, angularly blunt. Plate II, Figure 10.....**latigena** Tot.
*11. Beak of forceps wider and roundly blunt. Plate II, Figure 11.....**latifacies** Tot.
**7. Beak of forceps with well extended tip.
12. Lateral ridges of beak parallel, forceps densely bristled, abdomen without discals. Plate II, Figure 12.....**canadensis** Tot.
*12. Lateral ridges of beak not parallel.
13. Beak flat dorsally, hard part of probosis very short. Plate II, Figure 13.....**brevirostris** Tot.
*13. Beak concave dorsally, forceps very heavily bristled. Plate III, Figure 14.....**nivalis** Tot.
*1. Abdomen black or nearly so.
14. Second genital segment produced ventrally into a process bearing stout pines.
15. Processes of the accessory plates blunt and heavy, forceps large, beak long. Plate III, Figure 15.....**latianulum** Tot.
*15. Processes of the accessory plates sharply pointed, beak short.
16. Spines of ventral process long and comb-like, cleft of the fifth sternite V-shaped. Plate III, Figure 16.....**algens** Wd.
*16. Spines of the ventral process very short, beak very short, cleft U-shaped. Plate III, Figure 17.....**spineiventer** Tot.
*14. Second genital segment with no such processes.
17. Accessory plates reduced or nearly hidden from the lateral view.
18. Forceps small, beak reduced, parafrontals shining black. Plate III, Figure 18.....**latifrons** Tot.
*18. Forceps well developed, beak prominent.
19. Forceps laterally appearing like the head of a chicken with long beak. Plate III, Figure 19.....**rostrata** Tot.
*19. Forceps much larger, constricted in the middle; third segment of antennae truncate. Plate IV, Figure 20.....**nitida** v. d. W.

*17. Accessory plates distinctly visible from the lateral view.
20. Beak of forceps as broad as long, flat. Cleft acute on the bottom. Plate IV, Figure 21.....**latiforceps** Tot.
*20. Beak of forceps not as broad as long.
21. Lateral ridges of the beak not parallel, processes of the accessory plates flat on the inner surface. Plate IV, Figure 22.....**emarginata** Tot.
*21. Lateral ridges of the beak parallel, processes of the accessory plates round.
22. Beak gradually tapering to a sharp point, cleft U-shaped. Plate IV, Figure 23.....**piceifrons** Tns.
*22. Beak tapering abruptly to a blunt tip, forceps inflated on the caudal margin. Plate IV, Figure 24...**hispida** Tot.
22. Beak with long, sharp tip, forceps and accessory plates very large. Plate IV, Figure 25.....ampliforceps** n. sp.

DESCRIPTION OF SPECIES.

Fabriciella acuminata Tothill.

Canadian Entomologist, Vol. 24, 1925, p. 260.

Length, 8.5 mm. Parafrontals about as wide as half the length of the second segment of antennæ, black in ground color, white pollinose, bearing a few black hairs. Frontal vitta about as wide as parafrontals, reddish, widening near the antennæ. Frontals numbering eleven to fourteen. Ocellars pointing obliquely forward; verticles large, two pair at the apex of compound eye and two smaller pair posterior of the ocelli. Post-ocular row distinct. Post-ocular region covered with long yellow pile. Genæ narrower than the length of the third antennal segment, yellow pollinose, bearing scattered black hairs. Buccal region yellow pollinose, bearing mostly yellow hairs. Vibrissæ large. Vibrissal ridges distinct but not prominent, bearing three or four small bristles above the vibrissæ. Buccal row irregular, medium large. Antennæ reaching the lowest fifth of the facial depression, first and second segments yellowish brown, bearing a few bristles and black hairs; third segment nearly ovoid, dark brown to black. Arista black, tapering gradually, second segment at least four times as long as wide. Mouth parts normal. Labial palpi club shaped, yellow, and bearing short black hairs. Proboscis black, chitinized portion once and a half longer than antenna.

Pleura black, highly polished. Sternopleural bristles three. Notum black, highly polished. Dorsocentrals four. Scutellum at the base black, at the apex light brown. Marginal bristles of the scutellum eight in number, three pairs being large, the other pair reduced. Post-scutellum black. Length of left wing, 6.7 mm. Legs quite robust. Claws long, brown and curved near the tip.

Abdomen covered with small black bristles, yellow except for a black dorsal stripe which ends before reaching the posterior margin of the fourth tergite. Second segment bearing one pair of median marginal and two pairs of lateral marginal bristles. Margins of the third and fourth tergites bearing large bristles. Sternites all thickly set with

medium stout bristles. Genital segments prominent, dark brown or black.

Genitalia: (Plate I, Figure 1). First genital segment (G1) dark brown, polished, bearing a few medium large bristles on the dorsal surface; as wide as the second genital segment (G2) but narrowing on the ventral margins. Second genital segment distinctly brown, longer ventrally than dorsally, margin nearest the beak of the forceps (F) acutely angled, bearing black hairs on all surfaces. Accessory plates (AP) very prominent, fully a third as wide as the second genital segment, chocolate brown and highly polished. Processes of the accessory plates (PAP) nearly as long as the accessory plates, and very abruptly pointed. Anal area (AA) large. Forceps (F) flat, horizontal length not more than that of the accessory plates, beak of forcep very rudimentary, forcep bearing thick black hair on all surfaces except a small area near the beak. Posterior claspers (PC) very short, no longer than one-third the length of the anterior claspers (AC). Anterior claspers longer than the processes of the accessory plates, curved ventrally and anteriorly respectively. Penis (P) long, extending well past the processes of the fifth sternite. Fifth sternite (5St) as wide as genital segments, bearing medium high rounded, blunt processes. Cleft of the fifth sternite narrow, but as deep as half the length of the sternite.

Redescribed from a single specimen in the collection of the University of Utah, and determined by J. M. Aldrich, 1930.

Distributional records: Maple Canyon, Sanpete Co., Utah, 1923 (Shaler Aldous); Colorado.

Holotype: Male (B. and B. No. 52); Colorado; in the U. S. National Museum.

Paratype: Male, Colorado, (C. V. Riley); No. 810 in the Canadian National Collection, Ottawa.

Fabriciella cordiforceps, n. sp.

Length, 14.9 mm. Parafrontals dark in ground color, yellow pollinose, at the ocelli slightly narrower than the narrowest width of the frontal vitta, bearing numerous yellow hairs. Frontal vitta reddish-purple, narrowest width two-thirds the length of the second antennal segment. Frontals prominent. Vertex black in ground color, silvery pollinose. Post-ocular row ending before the ventral margin of the eye. Genæ at its narrowest width as wide as the length of the second antennal segment, yellow pollinose bearing short, scattered yellow hairs. Buccæ once and a half as wide as the genæ, yellow pollinose, and bearing only yellow hairs. Vibrissal ridges not prominent. Buccal row intact.

Second segment of the antennæ light brown, bearing numerous minute bristles and two medium large bristles on the dorsal margin; third segment black, except on the proximal third which is light brown. Arista two-thirds as long as the combined length of the second and third antennal segments, gradually tapering, the second segment at

least four times as long as wide. Mouthparts normal. Labial palpi yellow, and as long as the chitinized part of the proboscis. Proboscis from the articulation once and a third the length of the antennæ.

Pleura black, except for a spot of light brown above the sternopleura, polished. Sternopleurals three. Notum black in ground color, having intermittant spots of white pollinose, lateral border light brown. Dorsocentrals medium large, four. Scutellum brown, bearing five pairs of marginals and two pairs of sub-marginals. Length of right wing, 11.3 mm. Legs dark, the tibia of the second and third being distinctly lighter than the other segments. Claws of the second as long as the last two tarsal segments.

Abdomen orange, except for a shadow of black dorsal stripe. Anterior margin of each tergite silvery pollinose. Second tergite bearing a single pair of lateral marginals and a pair of median marginals. Genital segments small, orange.

Genitalia: (Plate I, Figure 2.) First genital segment (G1) small. Second genital segment (G2) twice as wide as long, irregularly brown and orange in color, exceedingly bristled on the dorsal surface. Accessory plate (AP) prominent, brown and highly polished. Processes of the accessory plates (PAP) curved ring like, their tips nearly touching, flat on the inner surface, and bearing a few light colored hairs. Forceps (F) small, brown except at the beak (B) which is black, slightly arched; when viewed from the caudal aspect, it appears heart shaped. Anal area (AA) oval. Posterior claspers (PC) shorter than the anterior claspers (AC) black and slightly curved. Penis (P) small, chitinized portion quite hidden by the anterior claspers. Fifth sternite (5St) orange, bearing only medium large bristles on the posterior half. Cleft of the fifth sternite (C5St) as deep as half the length of the segment, narrow at the bottom but widening rapidly at the top.

Holotype: Male, Pine Val. Mts., Utah, 7,000 feet, Brooklyn Museum Collection, 1929; in the Canadian National Collection, Ottawa.

Paratypes: Two males, Oak Creek Canyon, Arizona, 6,000 feet, August, F. H. Snow; in the Canadian National Collection, Ottawa. One male, same data as paratype above; in the collection of the University of Utah, Salt Lake City.

One female, same data; in the collection of the University of Utah.

Allotype: One female, same data as paratypes; in the Canadian National Collection, Ottawa.

Fabriciella florum Walker.

Echinomyia florum Wlk. 1849, Walker's List No. IV, 722.
Echinomyia dakotensis Tns. 1892, Trans. Am. Ent. Soc. XIX, 94.
Fabriciella orientalis Wlk. Tothill, Can. Entomologist, Vol 56, 1924, p. 259.

Length, 11.2 mm. Parafrontals wider than half the length of the second antennal segment, mostly black, polished, bearing scattered

black hairs. Frontal vitta at the narrowest width less than half the length of the second antennal segment, reddish brown. Post-ocular row distinct, running to the margin of the buccal region. Post-ocular pile white. Genæ as wide as two-thirds the length of the second antennal segment, white pollinose, bearing scattered black hairs. Buccal region about as wide as the combined length of the second and third antennal segments, golden pollinose bearing scattered black and yellow hairs. Buccal row intact. Vibrissal ridge prominent. First and second segments of the antennæ light brown, bearing numerous short black hairs; second segment with a medium large bristle on the dorsal surface; third segment laterally appearing subquadrate, dark brown to black. Arista brown, second segment at least four times as long as wide. Mouthparts normal. Chitinized portion of proboscis, heavy, slightly shorter than the combined length of the second and third antennal segments.

Pleura dark brown to black, highly polished. Sternopleurals three. Notum black, polished. Scutellum black except at the apex which is brown, bearing three pair of marginals, and two pairs of submarginals. Wings hyaline. Length of right wing, 8.7 mm. Legs quite robust, black.

Abdomen yellow except for a mid-dorsal black stripe. Second tergite bearing a pairs of median marginal bristles, and a single pair of lateral marginal bristles. Sternites somewhat darker in color than the tergites and heavily bristled. Genital segments subprominent, dark brown.

Genitalia: (Plate I, Figure 3.) First genital segment (G1) polished, black, slightly wider than the second genital segment (G2); dorsal width much greater than ventral width, dorsal surface bristled. Second genital segment polished, brown, bearing medium large bristles on only the dorsal surface; ventral width greater than dorsal width. Accessory plates (AP) strikingly large, brown, bearing no hair. Forceps (F) black, greatly flattened, projecting dorsally over the anal area (AA). Beak of forceps flat, sharply pointed, falcate, heavily chitinized. Processes of the accessory plates (PAP) slightly heavier than the posterior claspers, curved tusk-like, black, bearing a few small yellow hairs. Anal area (AA) large, somewhat spherical in shape. Posterior claspers (PC) heavier and shorter than the anterior claspers (AC), brown, strongly curved, and of an equal width throughout. Anterior claspers (AC) brown, longer and narrower than the posterior claspers. Penis (P) quite small, chitinized portion not projecting in front of anterior claspers, membraneous portion projecting in front of the anterior claspers a distance equal to half the length of a posterior clasper. Fifth sternite (5St) unusually large, as long as the combined length of the second genital segment and forcep. Cleft of the fifth sternite (C5St) as deep as half the length of sternite.

Redescribed from specimens determined and sent to me by Dr. J. M. Aldrich, March 28, 1930.

Distributional records: One female which shows the record of Forest Hills, Mass., 10–11–16, collector unknown. Martin

Falls and Nova Scotia, Canada; White Mountains, N. H. (Slosson); Axton, N. Y., (M. and H.); Province of Quebec, Canada, (Fyles).

The revision of 1934 recognizes *F. orientalis* Tns. and *F. dakotensis* Tns. as distinct species, but fails to recognize *F. florum* Wlk. on the basis of genitalia. These species have been checked, and although there are slight differences in colorations the genitalia are identical. I think the three are synonymous, and that the name should be *F. florum* Wlk. It is treated as such in this paper.

Fabriciella spinosa Tothill.

Canadian Entomologist, Vol. 56, 1924, p. 263.

Length, 12.4 mm. Parafrontals at their narrowest width, equal to about one-half the length of the second segment of the antennæ, dark in ground color, yellow pollinose, bearing a few weak bristles. Frontal vitta reddish, almost as wide as the length of second segment of antennæ. Frontals prominent. Ocellars medium large, pointing obliquely forward. Post-oculars prominent. Post-ocular region covered with long yellow pile. Genæ nearly as wide as second antennal segment, bearing scattered black pile. Buccal region bearing long black and yellow pile. Vibrissal ridges sub-prominent bearing few bristles above vibrissæ. Buccal row intact. Vibrissæ large. First and second segments of antennæ yellowish brown, third segment black except at its attachment where it is yellowish. Second segment bearing short stout spine near its distal end. Arista black and tapering gradually, second segment three times as long as wide. Mouth parts normal. Labial palps yellow and bearing short stout bristles on the distal end. Proboscis stout, once and a third as long as antennæ.

Pleura and venter polished black. Notum black except at the lateral margins which are brown, sub-polished at intervals, making it appear blue striped. Scutellum brownish, bearing three pairs of strong marginals and one pair of weak marginals. Post-scutellum prominent, white pollinose. Sternopleurals three. Dorsocentrals four. Legs rather robust, black except the tibia which is light brown. Claws large, yellow and tipped black. Wings hyaline. Length of right wing, 10.5 mm.

Abdomen yellowish brown, covered with stout short bristles. Second segment bearing a pair of median marginals, and a pair of lateral marginals. Genital segments prominent.

Genitalia: (Plate I, Figure 4.) Genital segments dark brown to black, first genital segment (G1) wider than the second genital segment (G2) and bearing medium large bristles on the dorsal surface. Second genital segment laterally appearing oval, bearing strong bristles on dorsal surface and a cluster of short stout spines near the margin just in front of the accessory plates. Accessory plates (AP) very distinct,

terminating in a tusk-like, abruptly pointed process (PAP). Forceps (F) rudimentary, knob-like, hardly projecting, covered with black hairs. Posterior claspers (PC) projecting ventrally, blunt and thickened on the end, about as long as the anterior claspers (AC) but not so stout. Anterior claspers pointing anteriorly, and slightly hooked on the end. Penis (P) longer than either claspers, chitinized portion rather thin. Genital sternum (GS) very prominent, and heavily chitinized. Fifth sternite (5St) large, covered with stout bristles. Processes of the fifth sternite (P5St) quite long, projecting posteriorly and blunt.

Redescribed from a series of six males in the collection of the University of Utah. Determined by Dr. J. M. Aldrich, 1930.

Distributional records: Maple Canyon, Sanpete Co., Utah, 1923 (Shaler Aldous); Parowan Canyon, Utah, 1923 (H. R. Hagen); Box Canyon, Sanpete Co., Utah, 1924 (H. R. Hagen), Brice Canyon, Utah (V. M. Tanner). Three males, same data as allotype and one male from Los Angeles Co., California, in the U. S. National Museum.

Holotype: Male, Peachland, B. C., 1917 (J. B. Wallis); No. 800 Canadian National Collection, Ottawa.

Allotype: Female, Mountains near Claremont, California (Baker); in Canadian National Collection, Ottawa.

Fabriciella lutzi Curran.

Canadian Entomologist, Vol 57, 1925, p. 256.

"Length, 13 mm. Male. Face, and cheeks yellowish in ground color. Head silvery white pruinose; frontal vitta rusty brown. Width of front one and three-sevenths greater than length of second antennal joint; parafacial five-sevenths as wide as length of second antennal joint; hair of occiput yellow, of cheeks yellow, coarse, with some black hairs intermixed, the parafacials with coarse yellow hair on lower half, black above. Front with fine yellow hairs along the orbits. Cheeks one-half as wide as eye height. Palpi yellowish. Antennæ reddish, third joint blackish.

Mesonotum rather thinly cinereous pollinose, the vittæ moderately distinct; humeri and lateral margins rusty-reddish. Scutellum rusty-reddish.

Legs black. Wings cinereous, yellowish antero-basally. Squamæ white; halteres orange.

Abdomen rusty yellow, darker apically; with a narrow median black vitta which is broadly interrupted on the third and fourth segments or narrowly so on the third, the spot on the third segment triangular, widest at apex, the fourth segment black on apical half. Bases of second to fourth segments broadly white pollinose, the second less widely so. Genitalia black. Intermediate abdominal segments without discals." (Curran's original description.)

Genitalia: (Plate I, Figure 5.) Genital segments dark brown to black. First genital segment (G1) polished, and bearing few or no large bristles. Second genital segment (G2) longer ventrally than dorsally, bearing numerous stout spines on the ventral half. Accessory plates (AP) well developed, dark-brown and polished. Processes of the accessory plates (PAP) long and narrow. Forceps (F) slightly arched, hairy. Beak of the forceps (B) very broad caudally, its lateral ridges parallel and its tip folded under. Anal area (AA) long and narrow. Posterior claspers (PC) greatly curved and slightly more prominent than the anterior claspers (AC). Fifth sternite darker caudally, its cleft (C) shallow and acute on the bottom.

Genitalia redescribed from a male, Richfield, Utah, August, 1930 (J. A. Rowe), in the collection of the University of Utah, Salt Lake City.

Holotype: Male, Rifle, Colorado, July 19–21, 1919, (F. E. Lutz); in the American Museum of Natural History.

Paratypes: Male, same data, No. 1443, in the Canadian National Collection, Ottawa. Male, near Lander, Wyoming, August, (Roy Moody); in the Kansas University Collection.

Fabriciella argentea n. sp.

Length, 11.1 mm. Narrowest width of the front less than the eye width. Parafrontals at their narrowest width equal to half the width of the frontal vitta; polished black above and yellow pollinose below. Post-ocular region yellow pollinose. Post-ocular pile thin and white. Narrowest width of the genæ equal to two-thirds the length of the second antennal segment, yellow pollinose and bearing scattered black hairs. Second segment of the antennæ dark brown, third segment oblong-oval, and nearly as long as the second. Arista thickened on at least the proximal three-fourths, second segment at least twice as long as wide.

Pleura polished black. Sternopleurals three and weak. Notum polished black. Dorsocentrals weak. Scutellum lighter than the notum, with five pairs of marginals and few prominent submarginals. Last segment of the tarsi silvery pollinose.

Abdomen with lateral orange spots. Sternites and ventral part of tergites and mid-dorsal stripe black. Second tergite with two pairs of median marginals, and four pairs of lateral marginals.

Genitalia: (Plate I, Figure 6.) Genital segments black. First genital segment (G1) polished black, and bearing a prominent dent at the middle of the dorsal surface. Second genital segment longer ventrally than dorsally, with few or no large bristles. Accessory plates (AP) prominent for their entire length, polished brown. Anal area (AA) oblong-oval. Forceps (F) distinctly arched. Beak (B) wide, concave, and with a sharp abruptly acuminate tip. Cleft of the fifth sternite (C) as deep as half the length of the sternite, acute on the bottom.

Holotype: Male, Banff, Alta., 9, viii, 1922, C. B. D. Garrett. In the Canadian National Museum, Ottawa.

Fabriciella longiunguis Tothill.

Canadian Entomologist, Vol. 56, 1924, p. 265.

"Width of front equal to three-fourths of the length of the second antennal segment. Second antennal segment a little longer than the third. Parafrontals opaque, narrowest width rather greater than that of the front. Genæ pollinose, with sparse black hairs above. Proboscis and palpi normal. Front tarsi slightly dilated, the claws as long as the last three tarsal segments. Abdomen, including the sternites, orange except for a dorsal black vitta that widens posteriorly to include most of the fourth tergite. Forceps strongly arched longitudinally and terminating in a broad somewhat concave shining plate". (Tothill's original description).

Genitalia: (Plate I, Figure 7.) Dr. J. McDunnough has kindly furnished the following notes on the genitalia of the Holotype. "Forceps bear heavy spines which are stoutest along lateral face and become longer posteriorly. There are fine hairs interspersed especially along median line.".

Holotype: Male, Vernon, B. C., no date, (M. H. Ruhmann); in the Canadian Nat. Collection, Ottawa.

Fabriciella pilosa Tothill.

Canadian Entomologist, Vol. 56, 1924, p. 263.

Length, 10.2 to 13.6 mm. Parafrontals at the ocelli one-half as wide as the frontal vitta, from the side appearing black, but from the front yellow pollinose except near the ocelli which is shining black. Front margin of the compound eye constricted making the front appear projecting. Frontal vitta reddish-purple, widening toward the antennæ. Frontals prominent. Vertex black. Verticles long. Post-ocular row ending before reaching the ventral margin of compound eye. Post-ocular region black except for intermittent light pollinose spots, pile dull yellow. Genæ at its narrowest part as wide as two-thirds the length of the second antennal segment, light pollinose and bearing many black hairs. Bucca brown in ground color, light pollinose and bearing many black hairs. Vibrissal ridge sub-prominent, bearing five or six bristles above vibrissæ. Vibrissæ small. Second segment of the antenna light brown, one-fifth longer than the third; third segment black except near the joint which is brown. Arista much shorter than the combined length of the second and third antennal segments, second segment slightly more than twice as long as wide; third segment heavy on proximal half and fine on distal half. Mouthparts normal. Labial palps yellow. Proboscis, from the articulation, almost twice as long as antennæ.

Pleura dark brown to black, polished, black pilose. Sterno-pleurals three and large. Notum black, pilose and polished. Dorsocentrals large. Post-scutellum lighter than notum, bearing seven pairs of large marginals. Length of right wing, 10.9 and 8.5 mm. Legs dark brown. Claws of the third only slightly longer than the last tarsal segment.

Abdomen polished, black except for an orange spot on the sides of the tergites, black pilose. Second tergite bearing three pairs of median marginals and three pairs of lateral marginals. Second and third tergites bearing four or five large distal bristles. Sternites thickly black pilose.

Genitalia: (Plate II, Figure 8.) First genital segment (G1) dark brown, polished, bearing few large bristles. Second genital segment (G2) brown, polished, black pilose but with few or no large bristles. Accessory plates (AP) very distinct from a lateral view, brown, not hairy. Processes of the accessory plates (PAP) black, round, long acuminate and sharp. Forceps (F) black, very hairy; from the lateral view appearing arched to the extent of over half the length of the second genital segment. Beak (B) almost round apically, flat, and concave dorsally. Anal area (AA) large extending nearly half the length of the second genital segment. Posterior claspers (PC) brown, equally as heavy as the anterior claspers (AC). Penis (P) prominent, extending in front of the anterior clasper to the extent of over half of the anterior claspers, membraneous part very pronounced. Fifth sternite (5St) very pronounced, appearing inflated. Cleft (C) deeper than half the length of the sternite, the bottom being very narrow. Processes of the fifth sternite (P5St) prominent and wide apart.

Redescribed from two paratypes: Male, Bear Lake, B. C., R. P. Currie, collector, No. 40145 in the U. S. Nat. Museum; loaned by J. M. Aldrich. Male, Hedley, B. C., July 25, 1923, C. B. Garrett, collector, No. 801 in the American Museum of Nat. History; loaned by C. H. Curran.

Paratypes: Five males, London Hill Mine, B. C., (R. P. Currie); three males, Hedley, B. C., July 25, 29, 1923, (Garrett); three males, Banff, Alta, August 9, (Garrett); one male, Truchas Peak, N. M. (W. P. C.); one male, White Mts., Scudder. In the U. S. National Museum.

Fabriciella montana (Townsend).

Echinomyia florum Coquillet (nec Walker). Rev. Tachin, 1897, p. 144.
Fabricioides montana Townsend, Insec. Inscit. Menstruus, Vol. 4, 1916, p. 26.
Fabriciella montana Tns. Tothill, Can. Entom., Vol. 56, 1894, p. 259, 265.

Length, 10.1 mm. Parafrontals at the ocelli slightly wider than half the width of the frontal vitta, black polished except for a strip near the compound eye which is yellow pollinose, bearing numerous black hairs above and scattered black hairs toward the antennæ. Frontal vitta brownish-red, almost continuous width throughout. Frontals of irregular

size, fourteen to sixteen in number. Vertex shining black. Postoculars ending before the ventral margin of the compound eye. Postocular region shining black except near the posterior ventral margin of the compound eye which is white pollinose. Narrowest width of the genæ slightly less than the length of the second antennal segment, brown in ground color, yellow pollinose, bearing many black hairs. Bucca for the most part polished brown, twice as wide as the genæ, and bearing many black hairs. Vibrissal ridges prominent. Vibrissæ only slightly larger than the bristles of the buccal row, which are large and numerous. Second segment of the antennæ longer than the third, brown; third segment black and showing tints of bronze under certain angles of light. Arista nearly as long as the second and third segments, heavy; second segment more than twice as long as wide. Mouthparts normal. Labial palpi dull yellow, slightly thickened distally. Proboscis from the articulation once and a half the length of the antennæ, brown.

Pleura polished black, hairy. Sternopleurals prominent. Notum black, polished, very hairy. Dorsocentrals not prominent. Scutellum brown, hairy, bearing many large marginals and few sub-marginals. Length of right wing, 9.8 mm. Legs dark brown, claws of the first as long as the last two tarsal segments.

Abdomen hairy, black except for a lateral orange spot on the first, second, and third tergites. Second tergite bearing three pairs of large lateral marginals, and three pairs of large median marginals.

Genitalia: (Plate II, Figure 9.) First genital segment (G1) dark brown to black, longer than the second genital segment (G2), bearing bristles on the lateral and dorsal surfaces. Second genital segment lighter than the first genital segment, bearing bristles and hairs on all surfaces. Accessory plates conspicuous brown, polished. Processes of the accessory plates (PAP) visibly short, round. Forceps (F) arched to the extent of about half its length, black and hairy. Beak caudally appearing long and straight, flat or slightly concave and very short acuminate. Anterior claspers (AC) larger and longer than the posterior claspers. Penis (P) extending far in front of the posterior clasper, chitinized portion prominent. Fifth sternite (5St) prominent heavily bristled. Cleft (C) wide at the bottom and narrow at the top appearing neck-like. Anal area (AA) very acute anteriorly and cutting deeply into the second genital segment.

Redescribed from two males: Male, Silverton, Colo., loaned by J. M. Aldrich, 1930. Male, Mt. Washington, collection of Mrs. A. T. Slosson, Ac. 26226; loaned by C. H. Curran, 1930.

Holotype: A male from White Mts., N. H., No. 19598 in U. S. Nat. Mus.

Other records: Male and female from White Mts., (Morrison), (B. & B. 55).

Fabriciella latigena Tothill.

Canadian Entomologist, Vol. 56, 1924, p. 262.

Length, 12 mm. Parafrontals at the ocelli slightly wider than half the length of the second antennal segment, ground color black, yellow pollinose. Frontal vitta narrower than parafrontals, reddish. Frontals large. Vertex dark. Ocellars large and curved obliquely forward. Post-ocular row distinct. Post ocular region covered with long white pile. Genæ wider than the length of the second antennal joint, yellow pollinose and bearing scattered black hairs below. Buccal region yellow, bearing small black hairs below, and bordered posteriorly by black hairs. Vibrissal ridge prominent, brownish, bearing few bristles above the vibrissæ. Vibrissæ large. Buccal row prominent. First and second segment of antennæ light brown, bearing small bristles. Third segment oblong, as long as second, black. Arista only slightly longer than the third antennal segment, second segment at least twice as long as wide. Arista abruptly tapering. Mouthparts normal. Labial palpi yellow, bearing small bristles on distal half, of a uniform width throughout. Proboscis black, chitinized portion once and a half as long as antennæ.

Pleura black, polished, sternopleurals three. Notum black, polished. Dorsocentrals four. Scutellum light brown, bearing three pairs of large marginals and one pair of weak marginals. Post-scutellum black in ground color, and white pollinose. Wings hayline. Length of right wing, 8.2 mm. Legs approaching black in color, all segments of legs except the tarsi bearing heavy bristles. Claws long, gently curved and spreading widely.

Abdomen yellow except for a black mid-dorsal stripe. Sternites bearing thick long weak bristles. Second tergite bearing two pairs of median marginals, and two pairs of lateral marginals. Genital segments prominent and black.

Genitalia: (Plate II, Figure 10.) Genital segments dark brown to black. First genital segment (G1) narrower than the second (G2), and bearing a few weak bristles. Second genital segment as wide as fifth sternite, and bearing weak bristles dorsally and black hairs laterally. Anal area (AA) large. Forceps (F) short but sharply pointed, and covered with short black hairs. Accessory plates (AP) conspicuous, a fourth as wide as the second genital segment. Processes of the accessory plates (PAP) curved, gradually tapering and about as long as the accessory plates. Fifth sternite (5St) broader than genitalia, and bearing numerous weak bristles on either side. Processes of the fifth sternite (P5St) hump like, not strongly chitinized. Posterior claspers (PC) slightly curving anteriorly, narrower and shorter than the anterior claspers. Anterior claspers (AC) abruptly pointed, heavier than posterior claspers. Penis (P) longer than either clasper, chitinized portion quite prominent.

Redescribed from a specimen bearing the label: Mt. Jefferson, Oregon. Determined by C. H. Curran, 1926. In the collection of the University of Utah.

Holotype: Male, Lillovet, B. C., 1917, 3,000 ft. (J. D. Tothill); No. 806 in the Canadian Nat. Collection, Ottawa.

Allotype: Female, Hedley, B. C., 1923 (C. B. D. Garrett).

Paratypes: Revelstoke Mt., B. C., 1923, (P. N. Vroom, R. Buchell); Hedley, B. C., 1923, (Garrett); Keremeose, B. C., 1923, (Garrett); Penticton, B. C., 1919, (Buchell); Lillovet, B. C., 1916, (A. W. Phair); Stein Mt. Dregon, 1922, (W. J. Chamberlin); Victor, Montana, 1918; Sparta, Oregon, 1922, (Chamberlin); Paratypes in the U. S. Nat. Museum and the California Academy of Sciences.

Fabriciella latifacies Tothill.

Canadian Entomologist, Vol. 56, 1924, p. 262.

Width of front at the ocellus equal to the eye width. Second antennal segment yellow, and longer than the third. Parafrontals opaque. Parafacials wider than the length of the second antennal segment. Genæ pollinose, with sparse mostly straw colored hairs. Probosis and palpi normal. Front tarsi not dilated, the claws as long as the last three tarsal segments. Front corners of the pronotum yellow. Abdomen yellow except for the shadow of a dorsal stripe on the first segment. Sternites and genital segments yellow.

Genitalia: (Plate II, Figure 11.) First genital segment (G1) brown, polished, bearing large bristles on all surfaces. Second genital segment (G2) brown, polished, unusually hairy on the ventral margin. Accessory plates (AP) prominent, polished. Processes of the accessory plates (PAP) round, quite narrow. Forceps (F) arched to the extent of over half its length, hairy. Beak of forceps (B) quite long its later ridges tapering gradually to the blunt tip. Posterior clasper (PC) heavier than the anterior clasper (AC). Penis (P) prominent. Cleft of the fifth sternite U-shaped, round on the bottom.

Redescribed from a single specimen loaned by C. H. Curran, 1931.

Holotype: Male, Ormsby Co., Nevada, July 6, (Baker); in the U. S. Nat. Museum.

Paratype: Male, Rogerson, Idaho, September 7, 1923, (Carl E. Duncan), reared from *Chrysothamnus*, in the Can. National Collection, Ottawa.

Fabriciella canadensis Tothill.

Canadian Entomologist, Vol. 56, 1924, p. 264.

"Width of frontal equal to one-half the eye width. Second antennal segment yellow and a little longer than the third. Parafrontals opaque. Narrowest width of parafacials slightly narrower than the front. Genæ pollinose with sparse black hairs above. Proboscis and palpi normal.

Front tarsi not dilated, the claws as long as the last two tarsal segments. Abdomen orange except for black dorsal vitta and fuscous sternites. Forceps strongly arched longitudinally, terminating in the usual broad shining somewhat concave plate." (Tothill's original description.)

Genitalia: (Plate II, Figure 12.) Dr. J. McDunnough has kindly furnished the following notes on the genitalia of the Holotype. "Forceps appear characteristic in having unusually dense, rather plumose hairs, especially along middle region beyond the slight concavity. This dense pilosity obscures the form of the posterior margin."

Holotype: Male, Godbout, Que., July 20, 1918, (E. M. Walker). No. 803, in the Canadian National Collection.

Paratypes: Male, same data as type; male, Nordegg, Alta., (J. McDunnough). In the Canadian National Collection. One male, same data as type in the U. S. National Museum.

Fabriciella brevirostris Tothill.

Canadian Entomologist, Vol. 56, 1924, p. 264.

Length, 12 mm. Parafrontals at the ocelli slightly wider than half the length of the second antennal segment, black near the vertex and yellow pollinose away from vertex, bearing no large bristles. Frontal vitta wider than half the length of the second antennal segment, blackish brown. Frontals medium large. Vertex black. Verticals large. Post-ocular row distinct. Post-ocular region covered with long white pile. Genæ wider than length of the second antennal segment, yellow pollinose and bearing scattered black hairs. Buccal region yellow pollinose, bearing scattered black hairs. Vibrissal ridge prominent, bearing bristles on at least its lower fourth. Vibrissæ median large. Buccal row prominent. First and second segments of antennæ light brown. Third segment oblong, dark brown to black, somewhat shorter than the second segment. Arista chocolate brown, tapering abruptly, second segment three times as long as wide. Mouthparts normal. Labial palpi yellow, of a uniform width, bearing small bristles on distal half. Proboscis unusually short, black chitinized part only slightly longer than the antennæ.

Pleura black, polished. Sternopleurals three. Notum black, polished. Dorsocentrals four. Scutellum dark brown, bearing three pairs of stout margins and three pair of weak marginals. Post-scutellum prominent and white pollinose. Wings hyaline. Length of right wing, 9 mm. Legs rather robust. Claws long and widely spread.

Abdomen foremost part yellow. Proximal half of first tergite, distal part of fourth, and mid-dorsal stripe, black. Second tergite of abdomen bearing one pair of median marginal and two pair of lateral marginal bristles. Genital segments prominent.

Genitalia: (Plate II, Figure 13.) Genitalia dark brown. First genital segment (G1) slightly smaller than the second (G2), bearing dorsally a few weak bristles and black hairs. Second genital segment somewhat inflated near the dorso-anterior margin, bearing scattered

black hairs. Anal area (AA) conspicuous. Forceps (F) about one-third as large as the second genital segment, very convex posteriorly, bearing short black hairs. Beak half as wide as forceps and gradually tapering. Accessory plate (AP) small somewhat hidden laterally by the second genital segment. Processes of the accessory plates (PAP) curved tusk-like, short, thick, tapering gradually, and sharply pointed. Fifth sternite (5St) slightly wider than the genital segments, deeply cleft, bearing weak bristles on lateral surfaces. Processes of the fifth sternite (P5St) short, blunt. Posterior claspers (PC) smaller than the anterior claspers (AC), projecting ventrally and curving gently anteriorly. Posterior claspers short and stout, knobed on posterior margin, slightly hooked on the end, and bearing a few small hairs. Penis (P) longer than either clasper, chitinized and membraneous portions prominent.

Described from a single specimen in the collection of the University of Utah, bearing the label Crater Lake Nat. Park. Determined by C. H. Curran, 1930.

Distributional records: Crater Lake, Nat. Park.

Holotype: Male, Kereneos, B. C., 1922, (C. B. D. Garrett); No. 809 in the Canadian Nat. Collection, Ottawa.

Paratypes: Male, Vernon, B. C., (M. H. Ruhmann); Midday Valley, B. C., 1921, (G. Hopping); two males, Summit Mt. Lowe, California, July 4, (J. M. Aldrich); male, Mt. Lowe, 1917, (Aldrich); the last three in the U. S. Nat. Museum.

Fabriciella nivalis Tothill.

Canadian Entomologist, Vol. 56, 1924, p. 264.

"Width of the front equal to three-fourths the length of the second antennal segment. Second antennal segment dull amber or fuscous in color. Parafrontals opaque except at the vertex which is partly shining and black. Narrowest width of the parafacials equal to that of the front. Genæ pollinose with sparse black hairs above. Proboscis and palpi normal. Front tarsi not dilated; the claws as long as the last two tarsal segments. Abdomen black except for dull orange sides." (Description from Tothill).

Genitalia: (Plate III, Figure 14.) Dr. McDunnough's notes on the genitalia of the Holotype are as follows: "Forceps very heavily spinose except on the slightly concave face. The heavy bristles on forceps are interspersed with finer hairs. Posteriorly the bristles become longer and more dense obscuring the form of the posterior margin."

Holotype: Male, Healey, Alaska, June 7, 1921, (J. M. Aldrich). In the U. S. National Museum.

Allotype: Same data.

Paratypes: Seven males and 17 females, same data; in the U. S. National Museum and No. 802 in the Canadian National Collection.

Fabriciella latianulum Tothill.

Canadian Entomologist, Vol. 56, 1924, p. 266.

Length, 14.7 mm. Parafrontals at ocelli half as wide as the length of second antennal segment, yellowish-white pollinose, bearing numerous black hairs. Narrowest width of frontal vitta half as wide as length of second antennal segment, chocolate brown. Frontals large, twelve to fourteen in number. Vertex black. Post-oculars medium large. Post-ocular pile golden. Genæ two-thirds as wide as the length of the second antennal segment, yellow pollinose and bearing scattered black hairs above. Bucca yellow pollinose and bearing scattered black hairs. Vibrissal ridge not prominent. Vibrissæ very large and curved. Buccal row not intact, a few large bristles on the lower part. First and second segment of the antennæ chocolate brown, bearing few small bristles; third black, velvety, two-thirds as long as the second. Arista black, tapering gradually, second segment at least three times as long as wide. Mouthparts normal. Labial palpi thickened on the distal half, light brown. Proboscis black, chitinized part once and a third as long as antennæ.

Pleura black, polished. Sternopleurals five. Notum black, polished. Dorsocentrals four. Scutellum brown, bearing four pairs of marginals. Post-scutellum very prominent, black in ground color, white pollinose. Wing hyaline. Length of right wing, 11.6 mm. Legs very robust, black. Claws long, brown, hooked near the end.

Abdomen black, polished. Second tergite bearing one pair of median marginals and one pair of lateral marginals. First sternite bearing a thick cluster of short heavy bristles. Genital segments very conspicuous.

Genitalia: (Plate III, Figure 15.) Genital segments black, polished. First genital segment (G1) as wide as second genital segment (G2) bearing medium large bristles. Second genital segment black, polished, hairy, produced ventrally into a flap-like, truncate, heavily chitinized, process which bears a row of stout, blunt spines. Anal area (AA) very prominent. Forceps (F) curved, stout, bearing long black hairs. Accessory plate (AP) very small almost hidden completely by the forceps. Processes of the accessory plate (PAP) heavy, blunt, and curving hook-like. Fifth sternite (5St) broad, covered with long black hairs. Processes of the fifth sternite (P5St) blunt, and quite slender, about half as long as posterior claspers (PC). Posterior claspers short, straight, and projecting ventrally. Anterior claspers (AC) stout, larger and longer than posterior claspers, bluntly falcate on the end. Penis (P) smaller than the outer claspers, quite heavily chitinized. Genital sternum (GS) prominent, widening below the penis.

Redescribed from five males sent to me by J. Wilcox, Corvallis, Oregon, and determined by J. M. Aldrich, 1930.

Distributional records: Corvallis, Oregon, 1925, (J. Wilcox); Mary's Peak, Oregon, 1926, (J. Wilcox); Three Sisters, Oregon, 1926, (H. A. Scullen).

Holotype: Male, Royal Oak, B. C., June 30, 1917, (B. H. Tothill); No. 813 in the Canadian National Collection, Ottawa.

Allotype: Female, Agassiz, B. C., August 22, 1921, (R. Glendenning).

Paratypes: Males, same data as type, in the U. S. National Museum. Fifty males and females, Royal Oak, Victoria, Vancouver, Agassiz, B. C.; male, July, 1921, Larder Lake, Northern Ontario, (H. C. Cook).

Fabriciella algens (Wiedeman).

Tachina algens Wd. Ausser. Zweif. Insekten, Vol. II, 185, Tachina N. A., 1830.
Nec. Echinomyia algens Wd. Coquillett's Rev. Tachinidæ, p. 144, 1897.
Fabriciella algens Wd. Tothill, Can. Ento., Vol. 56, p. 260, 1924.

Length, 13.7 mm. Parafrontals at the ocelli over half as wide as the frontal vitta, yellow pollinose and bearing scattered black hairs. Frontal vitta of a continuous width, slate gray. Frontals large. Vertex yellow pollinose. Verticals very large. Post-ocular row prominent, running well past the ventral margin of the compound eye. Post-ocular pile yellow. Genæ as wide as the length of the second antennal segment, yellow pollinose and bearing black hairs. Bucca once and one-half longer than the genæ, polished brown on posterior third, and bearing numerous black and yellow hairs. Vibrissæ large. Buccal row very prominent. Second segment of the antennæ dark brown and only slightly longer than the third. Third segment from the profile nearly oval, black. Arista heavy, nearly as long as the second and third segments of antennæ, second segment nearly three times as long as wide. Mouthparts normal. Labial palpi yellow, much enlarged distally. Proboscis black, chitinized part only slightly longer than antennæ.

Pleura black, polished, lower sclerites free from dense bristles. Sternopleurals large. Notum black, polished, hairy. Dorsocentrals conspicuous. Scutellum slightly lighter in color than the notum; bearing five pairs of marginals, the third pair enormous in size. Length of right wing, 10 mm. Legs black, claws of the first as long as the last three tarsal segments.

Abdomen somewhat cone-shaped, black above and lighter on the sides, polished. Second segment bearing one pair of median marginals and two pairs of lateral marginals. Second sternite thickly set with short stout spines. Genital segments unusually large.

Genitalia: (Plate III, Figure 16.) Genital segments black. First genital segment (G1) longer than the second genital segment (G2) bearing bristles only on the lateral surfaces. Second genital segment produced ventrally into a club shaped flap which is highly polished and bears a row of short, heavy, spines arranged in comb-like fashion on

the lateral margin. Accessory plates (AP) hidden, from the side, by second genital segment. Processes of the accessory plates (PAP) flat, angularly curved. Forceps (F) arched to the extent of over half its length, black hairy. Beak (B) short and quite curved. Claspers long and thin. Fifth sternite quite small, heavily bristled, black. Cleft (C) as deep as half the length of the fifth sternite, acute at the bottom gradually widening toward the center and narrowing again at the top thus giving it a diamond shaped appearance. Processes of the fifth sternite reflected inward.

Redescribed from a series of four males in the collection of the University of Utah, determined by J. M. Aldrich, 1930.

Distributional records: Ringwood, Tompine Co., N. Y., 1928, (H. A. Scullen); Lewis Lake, Yellowstone National Park, (V. M. Tanner); Fish Lake, June 17, 1926; Ithaca, N. Y., July, 1928, (H. A. Scullen); Carbon Co., Wyoming; Smiths Cove, N. S.; Salisbury and Fredericton, N. B.; Hastings, Trenton, Sudbury, Ottawa, Rainy River District, Ontario; Northwest Territories; Mt. Cheam, Agassiz, Penticton and London Hill Mine, B. C.; Franconia, New Hampshire.

Fabriciella spineiventer Tothill.

Canadian Entomologist, Vol. 56, 1924, p. 266.

Length, 12 mm. Parafrontals at the ocelli as wide as the frontal vitta, dark in ground color, yellow pollinose, and bearing few scattered small black hairs. Frontal vitta of a continuous width, maroon in color. Frontals large. Vertex black. Verticals large. Post-ocular row prominent, ending before reaching the buccal region. Post-ocular pile long and golden. Genæ slightly narrower than twice the width of the frontal vitta, yellow pollinose, bearing few black hairs on the lower third. Bucca wider than genæ, yellow pollinose, and bearing scattered black and yellow hairs. Vibrissæ prominent. Vibrissal ridge only sub-prominent. Buccal row not intact, only a few large bristles at the lower margin. Antennæ (the antennæ were missing on the only specimen available. Labial palpi yellow, distinctly thickened on the distal end, bearing short black bristles. Chitinized portion of proboscis longer than labial palpi.

Pleura chocolate brown, polished. Sternopleurals three. Notum dark brown to black, polished, dorsocentrals four. Scutellum lighter in color than the thorax proper, bearing three pairs of marginal bristles, and two pairs of sub-marginal bristles. Wings hyaline. Length of right wing, 9.6 mm. Legs chocolate brown.

Abdomen narrower than the thorax, conical, chocolate brown and highly polished. Second tergite bearing one pair of median marginals and two pairs of lateral marginals. Second and third sternites bearing thick clusters of short stout bristles. Fourth tergite bearing numerous large bristles, especially on the ventral surface. Genital segments very prominent, hairy, chocolate brown to black.

Genitalia: (Plate III, Figure 17.) Genital segments very pronounced. First genital segment (G1) fully as long as the second genital segment (G2), but somewhat narrower, bearing medium large bristles on dorsal and lateral surfaces. Second genital segment appearing oval from the side, somewhat inflated near the anterio-dorsal margin, ventral margin produced outward in the form of a ridge bearing a cluster of short stout spines. Accessory plates (AP) indistinct, almost hidden by the forceps (F). Forceps small, only about one-sixth as large as second genital segment. Beak short, dorsal margin sharply ridged. Dorsal and lateral surfaces of forceps densely covered with black hair. Anal area (AA) large, almost reaching one-third the length of the second genital segment. Processes of the accessory plates (PAP) flat, robust, about as long as posterior claspers and bearing fine yellow hair on the inner surface. Posterior claspers (PC) well developed, slightly curved and thickened on the end, slightly longer than anterior claspers. Anterior claspers (AC) well developed and slightly hooked on the end. Chitinized part of penis (P) as wide as the width of posterior claspers, membraneous part, more than half as long as posterior clapers. Fifth sternite (5St) conspicuously prominent, cleft shallow, all surfaces of sternite bearing medium large bristles and black hairs. Processes of fifth sternite (P5St) about half as long as depth of cleft.

Redescribed from a single male paratype labeled Moscow, Idaho, (J. M. Aldrich); loaned to me and determined by Dr. J. M. Aldrich, 1930.

Holotype: Male, Mt. McLean, B. C., 8,000 ft., 1917, (J. D. Tothill); No. 812 in the Canadian Nat. Collection, Ottawa.

Paratypes: Male, Moscow, Idaho, (J. M. Aldrich); in the collection of J. M. Aldrich. Male, Vancouver, B. C., 1923, (D. E. Osburn).

Fabriciella latifrons Tothill.

Canadian Entomologist, Vol. 56, 1924, p. 260.

Length, 12.7 mm. Parafrontals at ocelli slightly more than half as wide as the frontal vitta, for the most part polished black, bearing scattered black hairs. Frontal vitta of a continuous width, dark reddish-purple. Frontals large, the row nearly reaching the compound eye. Vertex black in ground color, white pilose in intermittent spots. Verticals conspicuous. Post-ocular row running well past the ventral margin of the compound eye. Post-ocular region white pollinose. Post-ocular pile golden. Genæ at its narrowest width about two-thirds the length of the second antennal segment, yellow pollinose and bearing a few scattered black hairs. Bucca fully twice as wide as the genæ, yellow pollinose and bearing scattered black and yellow hairs. Buccal row prominent. Vibrissal ridge polished brown, bearing only two or three bristles above the vibrissæ. Vibrissæ very heavy. Second segment of the antennæ dark brown or black. Third segment black

and appearing from the side nearly oval. Arista two-thirds as long as the combined length of the second and third antennal segments, gradually tapering, second segment nearly three times as long as wide. Mouth parts normal. Labial palpi light brown, much thickened distally. Proboscis black, a third longer than the antennæ.

Pleura black, polished. Sternopleurals three, prominent. Notum black, polished, and quite hairy. Dorsocentrals medium large. Scutellum slightly lighter in color than the notum, bearing five pairs of marginals and several submarginals. Length of right wing, 8.7 mm. Legs black. Claws of the third only slightly longer than the last tarsal segment.

Abdomen black, polished. Second tergite bearing a pair of median marginals and a pair of lateral marginals. Bristles of the fourth tergite very stout.

Genitalia: (Plate III, Figure 18.) All genital segments black, bearing few or no large bristles. First genital segment (G1) hairy but bearing few or no bristles. Second genital segment very large, many times larger than forceps (F), anterior margin much wider than posterior margin, hairy. Accessory plates reduced, hidden laterally by second genital segment, its processes (PAP) only half exposed, and flat on the inner surface. Anal area (AA) small, oblong oval. Forceps small, black, its beak (B) becoming unusually short and truncate. Posterior claspers curved greatly, about the same length as the anterior claspers. Penis (P) short and heavy, projecting portion several times larger than the anterior claspers (AC). Fifth sternite (5St) characteristically narrowed posteriorly, its cleft (C) being shallow and U-shaped, its processes (P5St) being prominent.

Original diagnosis by Tothill only in his key to species. He does not publish data as to types and their location. Holotype apparently in Can. Nat. Coll., Ottawa.

Redescribed from a paratype male, Aweme, Man., VII–28, 1920, H. A. Robertson; No. 811 in the American Museum of Natural History. Kindly loaned to me by Dr. C. H. Curran.

Distribution records: Hedley, B. C., 1923, C. B. Garrett; Aweme, Man., 1920, H. A. Robertson; N. W. T.; S. D. and Colo., *vide* Tothill, (loc. cit., p. 269).

Fabriciella rostrata Tothill.

Canadian Entomologist, Vol. 56, 1924, p. 267.

Length, 14.5 mm. Vibrissal ridge prominent and bearing few bristles above the vibrissæ. Vibrissæ very large. Buccal row prominent. Genæ and facial depression, yellow pollinose. Buccal region bearing scattered black and yellow pile. Front wider than the length of the second antennal segment. Parafrontals dark and bearing several strong bristles. Frontals nine to twelve in number. Ocellars pointing obliquely forward. Post-ocular row distinct. Post-ocular region covered with long yellow pile. First two segments of antennæ chocolate

brown, third segment black, except at the point of attachment which is reddish brown. Arista long and tapering, its second segment twice as long as wide. Mouth parts normal. Labial palpi well developed, yellowish brown, and bristled on the distal end. Proboscis black, one and a third times as long as the total length of the antennæ.

Pleura and notum polished. Dorsocentrals four. Sternopleurals three. Post-scutellum lighter in color than the notum, bearing three pairs of strong marginals and one pair of weaker marginals. Legs rather robust, black. Tarsal claws well developed, yellowish, darkening toward the tip. Wings hyaline. Length of right wing, 11 mm.

Abdomen black, convexed dorsally, polished. Second tergite bearing one pair of heavy median marginals, a single pair of lateral marginals. Sternites all bearing heavy bristles. Genitalia conspicuously prominent.

Genitalia: (Plate III, Figure 19.) First genital segment (G1) prominent, black and bearing weak bristles on the dorsal and laterodorsal surface. Second genital segment (G2) very prominent, black, polished, bearing small bristles on all surfaces. Forceps (F) characteristically shaped like the head of a chicken. Accessory plates (AP) small, almost hidden by forceps and second genital segment. Processes of the accessory plates (PAP) many times longer than forceps and curving tusk-like, abruptly acuminate. Fifth sternite (5St) prominent, bearing weak bristles near the sternal processes. Process of fifth sternite (P5St) medium long, bluntly rounded at the tip. Posterior claspers (PC) nearly as long as the anterior claspers (AC), and gently curving toward them. Anterior claspers as long as visible portion of the penis (P) pointing anteriorly and heavily chitinized.

Redescribed from a series of 14 males in the collection of the University of Utah. Determined by Dr. J. M. Aldrich, 1930.

Distributional records: Cedar City, Utah, 1919, (H. R. Hagan); Vancouver, Washington, 1911, (M. W. Reeves).

Holotype: Male, Penicton, B. C., 1913, (E. M. Anderson); No. 814 in Canadian Nat. Collection, Ottawa.

Allotype: Female, Hedley, B. C., 1923, (C. D. Garrett).

Paratypes: Male, Grow Agency, Montana, (R. Kellogg); male, Okanagan, B. C., (T. Wilson); male, Mt. McLean, B. C., (A. W. Phair); male, Dunvegan, Alta., (E. H. Strickland); two males, Lethbridge, Alta., 1921, (E. H. Strickland); four males, Lethbridge, Alta., 1921, (H. L. Seamans); male, Lethbridge, 1921, (W. Carter); two males, Baniff, Alta., 1922, (Garrett); four males, Hedley, B. C., 1923, (Garrett).

Fabriciella nitida van der Wulp.

Jurinia nitida v. d. W. Notes from the Leyden Mus., Vol. 4, p. 82, 1882.
Fabriciella nitida v. d. W. Tothill, Can. Ento., Vol. 56, p. 268, 1924.

Length, 13 mm. Head wider than long. Parafrontals at the ocelli slightly more than half as wide as the length of the second antennal

segment, black polished along a strip on each side of the frontal row, yellow pollinose on a strip near the eye. Frontal vitta reddish, light pollinose, wider than half the length of the second antennal segment. Ocellars medium large, and pointing obliquely forward. Post-ocular row pominent. Post-ocular pile yellow. Frontals prominent, curving inward and nearly reaching the eye. Genæ narrower than second antennal segment, yellow pollinose, and bearing a few weak hairs. Bucca golden pollinose, darkening ventrally, bearing a few weak hairs. Vibrissal ridges prominent, and bearing few bristles above vibrissæ. Vibrissæ large. Buccal row intact, lower bristles large. First and second segment of the antennæ dark brown; third segment black, large, and ax-blade shaped. Arista long and tapering abruptly, black, combined length of first and second segments nearly equal to that of the third. Mouthparts normal. Labial palpi rather short, stout, yellow, and bearing short spines. Proboscis long, slender, and black.

Pleura black and polished, its sclerites bearing numerous heavy bristles and long black pile. Sternopleurals three. Notum black, polished. Dorsocentrals four. Scutellum dark brown, bearing three pairs of large marginals and one pair of weak marginals. Post-scutellum faintly white pollinose. Wings hyaline. Length of right wing, 11 mm. Legs robust, black. Claws long, and darkening near the tip.

Abdomen black and polished. Second tergite bearing one pair of median marginal and one pair of lateral marginal bristles. Genital segments very prominent.

Genitalia: (Plate IV, Figure 20.) Genital segments black and polished. First genital segment (G1) as wide as the second genital segment (G2), bearing scattered long black hairs. Second genital segment inflated dorsally near the anterior margin, tapering posteriorly, bearing scattered black hairs dorsally and thick black hairs on the ventro-lateral margins. Anal area (AA) large. Forceps (F) well developed, and constricted in the middle, covered dorsally and laterally by long black hairs. Accessory plates (AP) small, hidden laterally by second genital segment. Processes of the accessory plates (PAP) about as long as anterior claspers, curved inward and toward the forceps, sharply pointed and tapering gradually. Fifth sternite (5St) broad, bearing thickly set medium large bristles ventrally and black hairs laterally. Processes of the fifth sternite (P5St) blunt, curving gently dorsally. Posterior claspers (PC) shorter than the anterior claspers (AC), about the same width. Posterior claspers with a large base, gently hooked on the end. Penis (P) longer than either clasper, chitinized portion prominent, membraneous portion long. Genital sternum inconspicuous.

Types in Leyden Museum.

Redescribed from a single specimen sent to the author by J. Wilcox, Corvallis, Oregon, and determined by J. M. Aldrich, 1930.

Distributional records: Anthony Lake, Oregon, 1929, (H. A. Scullen); Fort Bridge, Wyo., 1926, (C. Cottam); British

Columbia; Colorado; Toronto, Canada; White Mountains and Franconia, N. H.; Vermont; New Bedford, Mass.; Oswego, N. Y.; Montana; Washington; California.

Fabriciella latiforceps Tothill.

Canadian Entomologist, Vol. 56, 1924, p. 266.

Length, 13 mm. Parafrontals at the ocelli half as wide as the frontal vitta, black above and yellow pollinose, below bearing scattered black hairs. Frontal vitta widening as it approaches the antennæ. Frontal row sub-prominent. Vertex and dorsal half of the post-ocular region polished black. Verticals medium long. Post-ocular row reaching the ventral margin of the compound eye. Post-ocular pile yellow. Narrowest width of genæ equal to four fifths of the second antennal segment, yellow pollinose and bearing scattered black hairs. Bucca more than twice as wide as the genæ, thinly pollinose on the anterior half and bearing many black hairs. Facial ridges prominent, light brown. Vibrissæ only medium large. Buccal row inconspicuous. Second segment of the antennæ brown, almost twice as long and nearly as wide as the third. Third segment black, quite small. Arista heavy, tapering gradually, second segment slightly more than twice as long as wide. Mouthparts normal. Labial palpi yellow, enlarged distally. Chitinized part of proboscis no longer than antennæ.

Pleura polished black. Sternopleurals medium large. Notum polished black. Dorsocentrals small, four. Scutellum slightly lighter in color than the notum, bearing four pairs of marginals and few or no sub-marginals. Length of right wing, 10.6 mm. Legs black. Claws of the first nearly as long as the last two tarsal segments.

Abdomen black dorsally, lighter laterally, polished. Second tergite bearing two pairs of median marginals, and two pairs of lateral marginals.

Genitalia: (Plate IV, Figure 21.) Genital segments sub-prominent, brown except the forceps which are black. First genital segment (G1) bearing few or no large bristles, darker than the second genital segment (G2). Second genital segment from the side appearing no more than four times as large as the forceps, brown, bearing few or no large bristles. Accessory plate (AP) distinct, but appearing reduced. Anal area (AA) extremely large, acute on margin opposite forceps. Forceps (F) black, hairy, arched to almost the extent of half its length. Beak (B) broad, concave and short acuminate. Processes of the accessory plates (PAP) round. Anterior claspers (AC) heavier and longer than the posterior claspers (PC). Posterior claspers nearly straight. Membraneous portion of the penis (P) prominent. Fifth sternite (5St) black, bearing many bristles. Cleft (C) distinctly V-shaped.

Redescribed from a single male specimen, Mt. Katahdin, Me., Camp Kennedy, 3,000 feet, August, 1902; determined and sent to me by J. M. Aldrich, 1930.

Holotype: Male, Gadbout, Quebec, July 25, 1918, (E. M. Walker); No. 804 in the Canadian National Collection.

Paratypes: Male, same data as holotype, in the U. S. Nat. Museum; Banff, Alta., June 30, 1922, (C. B. D. Garrett); male, Mt. Revelstoke, B. C., August 12, 1923, (E. R. Buckell). In the Canadian National Collection.

Fabriciella emarginata Tothill.

Canadian Entomologist, Vol. 56, 1924, p. 260.

Length, 14.5 mm. Parafrontals at the ocelli narrower than half the length of the second antennal segment reddish. Post-ocular row distinct, reaching the buccal region. Post-ocular pile yellow. Genæ as wide as half the length of the second antennal segment, yellow pollinose, reddish in ground color, bearing scattered black hairs. Buccal region as wide as length of second antennal segment, reddish in ground color, yellow pollinose. Vibrissæ very large. Vibrissal ridge prominent on at least the upper half. First and second segments of the antennæ dark brown; third segment black, laterally sub-quadrate. Arista black, long, tapering gradually; second segment at least three times as long as wide. Mouthparts normal. Labial palpi yellow, narrowing slightly toward the base. Chitinized portion of the proboscis slightly longer than the combined length of the last two antennal segments.

Pleura dark brown to black, polished. Sternopleurals four. Notum black except at the margins which are dark brown. Dorsocentrals four. Scutellum dark brown, bearing five pairs of large marginals and three pairs of large sub-marginals. Wings hyaline. Length of right wing, 10.7 mm. Legs robust, black except for the tibia of the second and third which are distinctly brown. Claws long, and black tipped.

Abdomen dark brown except on the mid-dorsal line where the color is nearly black. Second tergite bearing a pair of large median marginals and three pairs of large lateral marginals. Third tergite bearing a row of large marginal bristles. All sternites bearing medium large bristles. Genital segments, sub-prominent and brown.

Genitalia: (Plate IV, Figure 22.) Genital segments highly polished, chocolate brown. First genital segment (G1) slightly smaller than the second genital segment (G2), acutely angled on the ventral margin, bearing medium large scattered bristles on the dorsal surface. Second genital segment somewhat inflated at the dorso-anterior margin, bearing black hairs on all surfaces and a few medium large bristles on the dorsal surface. Accessory plates (AP) quite conspicuous except at the ventral margins where they are hidden by the second genital segment. Processes of the accessory plates (PAP) short, curved, convex on the external surface, flat on the inner surface. Forceps (F) ventrally flat, sharp pointed, somewhat disc-shaped, upper portion bearing thickly set long black hairs. Posterior claspers (PC) longer, and as stout as the anterior claspers (AC) and curved anteriorly. Anterior claspers (AC) projecting ventrally and anteriorly respectively, slightly curved at the tip, and expanded near the middle. Penis (P) much longer than either clasper, chitinized portion very prominent, projecting below the anterior clasper; membraneous portion very conspicuous about as long as the

distal half of the anterior clasper. Fifth sternite (5St) broader than the genital segments. Processes of the fifth sternite (P5St) knob-like and bending laterally, heavily chitinized. Cleft (C) characteristically U-shaped.

Redescribed from a single specimen sent to me and determined by Dr. J. M. Aldrich, 1930.

Fabriciella piceifrons (Townsend).

Echinomyia algens Coquillett (nec. *Tachina algens* Wied), Rev. Tach., 1897, p. 144.
Echinomyodes piceifrons Townsend, Insec. Inscit. Menstruus, Vol. 4, 1916, p. 25.
Fabriciella piceifrons Tns., Tothill, Can. Ent., Vol. 56, 1924, p. 265.

Length, 15.8 mm. Parafrontals at the ocelli less than one-half the width of the frontal vitta, shining black, bearing numerous black hairs. Frontal vitta at its narrowest width three-fourths as long as the second antennal segment. Frontals prominent. Vertex dark, pollinose in certain regions. Post-ocular row prominent, running well into the buccal cavity. Post-ocular pile golden. Narrowest width of the genæ two-thirds the length of the second antennal segment, yellow pollinose and bearing scattered black hairs. Buccæ at least twice as wide as the genæ, for the most part shining brown, and bearing numerous black hairs. Vibrissal ridges prominent. Vibrissæ only slightly more prominent than the bristles of the buccal row. Second segment of the antennæ one-third longer than the third, dark brown; third segment black, except near the joint which is brown, quite truncate. Arista two-thirds as long as the combined length of the second and third antennal segments, thin on the apical half, second segment three times as long as wide. Mouthparts normal. Labial palpi light brown. Proboscis from the articulation one-fourth longer than antennæ.

Pleura black, polished. Sternopleurals large. Notum black, polished. Dorsocentrals large. Scutellum as dark as notum, bearing four pairs of very large marginals and numerous sub-marginals. Length of right wing, 10.7 mm. Legs dark brown or black, bearing many large bristles, claws of the first longer than the last two tarsal segments.

Abdomen dark brown, lighter ventrally, bearing numerous heavy bristles. Second tergite bearing one pair of large medium marginals, and two pairs of large lateral marginals.

Genitalia; (Plate IV, Figure 23.) Genital segments except the forceps dark brown. First genital segment (G1) about equal to the second genital segment (G2). Bristles on the dorsal surface. Second genital segment inflated on the dorsal surface, and bearing bristles on all surfaces. Accessory plates (AP) almost hidden by the second genital segment. Anal area (AA) large, acutely angled opposite the forceps. Forceps (F) black, arched to half its length, very hairy. Beak (B) flat, acutely pointed, somewhat concave dorsally. Processes of the accessory plates (PAP) with tips touching, flat on inner surface. Fifth sternite brown, very bristly, its cleft (C) deep and wide at the bottom, almost quadrate, processes of the fifth sternite (P5St) prominent and reflected outward.

Redescribed from two males: Springfield, Mass., (G. Dummock), No. 11138 in Dummock's Entomological Notes, sent to me by Dr. J. M. Aldrich, 1930. Platte, 8.16 : 77, (Curran collection) sent to me by C. H. Curran, 1930.

Holotype: A female from Vermont, No. 19597 in U. S. Nat. Mus.

Distributional records: Trenton and Sudbury, Ontario; Northwest Territories; Melrose Hylands, Mass.; Uinta National Forest Park, Utah; and Morrison, Colorado.

Fabriciella hispida Tothill.

Canadian Entomologist, Vol. 56, 1924, p. 265.

Length, 14.4 mm. Parafrontals at the ocelli narrower than half the length of the second antennal segment, yellow pollinose and bearing scattered black hairs. Frontal vitta of a continuous width, more than half as wide as the length of second antennal segment, maroon. Frontals medium large. Vertex black, polished. Verticals large. Post-ocular row distinct, ending above the ventral margin of the compound eye. Post-ocular pile golden. Genæ wider than half the length of the second antennal segment, golden pollinose, bearing a few small black hairs. Buccal region as wide as the length of the second and third antennal segments, golden pollinose, bearing scattered black and yellow hairs. Vibrissæ medium large. Vibrissal ridges distinct, prominent on at least the upper half. First and second segments of the antennæ light brown, bearing small bristles; third black, laterally sub-quadrate, not more than half as long and once and a half as wide as the second segment. Arista brown, small, tapering gradually; second segment three times as long as wide. Mouthparts normal. Labial palpi slightly longer than the antennæ. Proboscis slender, chitinized part once and a third as long as the antennæ.

Pleura dark brown, polished. Sternopleural bristles four. Notum black, polished. Dorsocentrals four. Scutellum brown, bearing four pairs of large marginals and three pairs of large submarginals. Post-scutellum large, black. Wings hyaline. Length of right wing, 11.5 mm. Legs chocolate brown, all segments bearing numerous bristles. Claws small yellow.

Tergites chocolate brown except at the mid-dorsal line where they are black. Sternites chocolate brown, bearing numerous medium large bristles. Second tergite bearing three pairs of large median marginals, and five pairs of lateral marginals. Third tergite with a conspicuous row of large marginal bristles. Genital sub-prominent.

Genitalia: (Plate IV, Figure 24.) Genital segments black or brown in color. First genital segment (G1) black, polished, acutely angled ventro-anteriorly, bearing medium large bristles on the dorsal and lateral surfaces. Second genital segment (G2) black on the dorsal surface and distinctly brown on the lateral, projecting over the accessory plate on the ventro-posterior region, bearing medium large bristles on

only the dorsal surface. Accessory plates (AP) prominent from the ventral and posterior aspect, partly hidden from the lateral view, brown. Processes of the accessory plates (PAP) round, curved tusk-like and medium long, bearing a few brown hairs on the inner surface. Forceps (F) black, polished, horizontal diameter much less than that of the second genital segment, somewhate inflated on the medio-posterior region, thickly beset with black hair giving a tufted appearance. Beak (B) of forceps sharp pointed and flat. Ventrally appearing shield shaped. Anal area (AA) prominent, diamond shaped. Posterior clasper (PC) brown, about as long as the distal half of the anterior clasper (AC) gently curved and bluntly tipped. Anterior clasper (AC) brown, projecting posteriorly and ventrally respectively; ventral projection inflated near the middle and somewhat hooked on the end, bearing a few scattered yellow hairs. Penis (P) longer than either clasper, membraneous portion characteristically dark in color. Fifth sternite (5St) broader than genital segments, chocolate brown, lateral surfaces bearing numerous closely set medium large bristles. Processes of the fifth sternite (P5St) at least half as deep as the length of fifth sternite, V-shaped.

Redescribed from a single specimen loaned to me and determined by Dr. J. M. Aldrich, 1930.

Holotype: Male, Sudbury, Ont.; Ottawa, No. 805 in the Canadian Nat. Collection.

Allotype: Female, same data.

Paratypes: Three males, same data as type; one female, northern Ontario; male, Kentville, N. S.; male, Frederickton, N. B., (J. D. Tothill); male, Hastings Co., Ont., (Evans); in the Canadian Nat. Collection, Ottawa.

Fabriciella ampliforceps n. sp.

Length, 15.2 mm. Front wider than the length of the second antennal segment. Parafrontals at the ocelli, narrower than the half of the width of the frontal vitta, yellow pollinose and bearing numerous black hairs. Post-ocular region yellow pollinose. Post-ocular pile golden. Narrowest width of the genæ equal to two-thirds the length of the second antennal segment, yellow pollinose and bearing many black hairs. Bucca yellow pollinose and bearing both black and yellow hairs. Vibrissal ridges distinct and polished brown. Second segment of the antennæ light brown; third somewhat quadrangular, two-thirds as long as the second. Arista heavy, almost as long as the combined length of the last two segments of the antennæ.

Pleura black and polished. Sternopleurals five. Notum polished black, except on the humeral callæ which is thinly white pollinose. Dorsocentrals four. Scutellum slightly lighter than the notum, with four pairs of marginals and three pairs of submarginals. Last segment of the tarsi bearing numerous long bristles. Pulvilli greatly developed, almost as long as claws.

Abdomen black and polished. Apical tergites with numerous long bristles. Sternites with thickly set long bristles. Second tergite with four pairs of median marginals, and five pairs of lateral marginals.

Genitalia: (Plate IV, Figure 25.) Genital segments dark brown to black. First genital segment (G1) polished, as large as the second genital segment (G2) and with few or no large bristles. Second genital segment lighter, and with few or no large bristles. Accessory plates triangular, with the apex dorsally. Processes of the accessory plates (PAP) normally hidden by the ventral margins of the second genital segment. Forceps (F) laterally appearing at least one-third as large as the second genital segment, elongated. Beak (B) with short parallel ridges and medium large acuminate tip. Anal area (AA) large. Posterior clasper (PC) almost straight. Anterior clasper (AC) regular. Cleft of fifth sternite (C) U-shaped, round on the bottom.

Holotype: Male, Mahone Bay, 9, viii, C. A. Hamilton; in the Canadian National Collection, Ottawa.

Paratype: Male, Cowley, Alta., 20, vi, 1918, R. N. Christal; in the collection of the University of Utah, Salt Lake City.

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EXPLANATION OF ABBREVIATIONS.

F.....forceps
AA.....anal area
AP.....accessory plates
PAP, processes of the accessory plates
G1.....first genital segment
G2.....second genital segment
PC.....posterior claspers
AC.....anterior claspers
GS.....genital sternum
P.....penis
Sp.....spiracle
M.....membrane
4Tg.....fourth tergite
5 St.....fifth sternite
C.....cleft of the fifth sternite

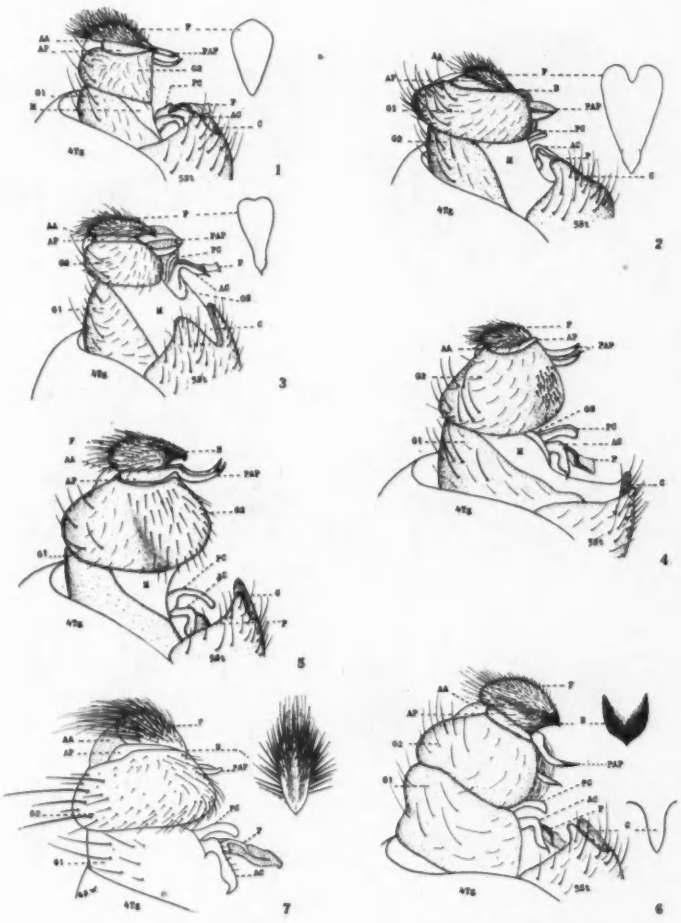


FIG. 1. *Fabriciella acuminata* Tot.
FIG. 2. *Fabriciella cordiforceps* n. sp.
FIG. 3. *Fabriciella florum* Wlk.
FIG. 4. *Fabriciella spinosa* Tot.
FIG. 5. *Fabriciella lutzi* Curr.
FIG. 6. *Fabriciella argentia* n. sp.
FIG. 7. *Fabriciella longiunguis* Tot.

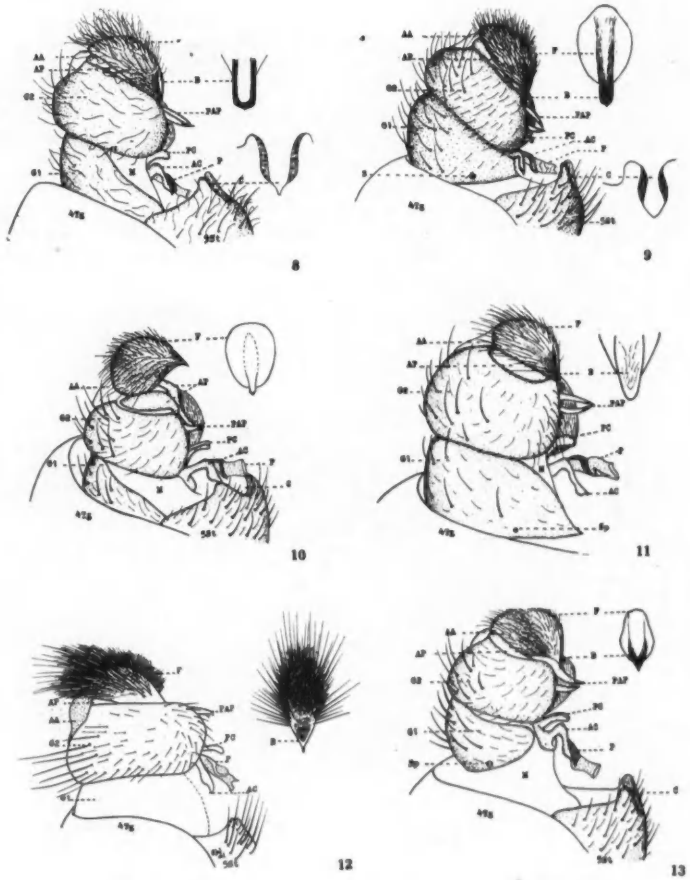
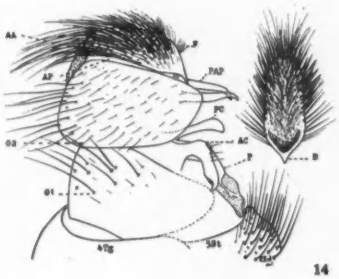


FIG. 8. *Fabriciella pilosa* Tot.
FIG. 9. *Fabriciella montana* Tns.
FIG. 10. *Fabriciella latigena* Tot.
FIG. 11. *Fabriciella latifacies* Tot.
FIG. 12. *Fabriciella canadensis* Tot.
FIG. 13. *Fabriciella brevirostris* Tot.



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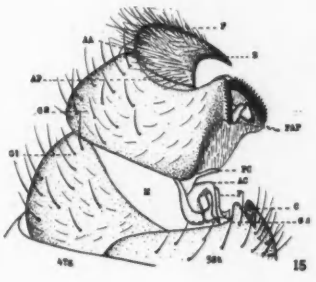

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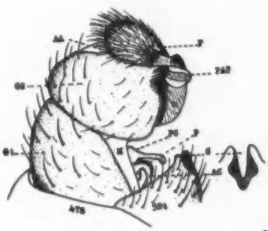

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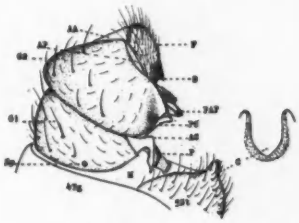

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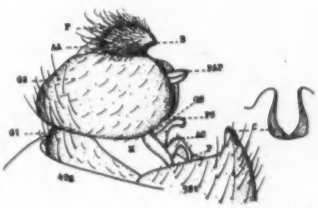

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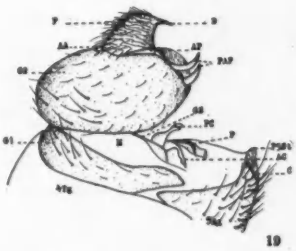

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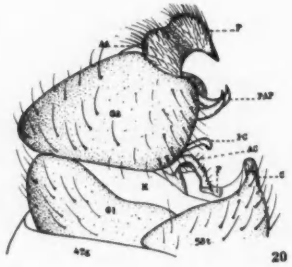
FIG. 14. *Fabriciella nivalis* Tot.
FIG. 15. *Fabriciella latianulum* Tot.
FIG. 16. *Fabriciella algens* Wd.
FIG. 17. *Fabriciella spineiventer* Tot.
FIG. 18. *Fabriciella latifrons* Tot.
FIG. 19. *Fabriciella rostrata* Tot.



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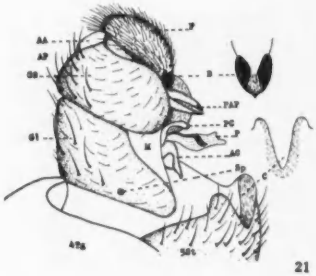

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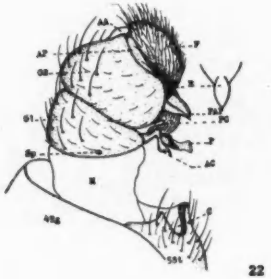

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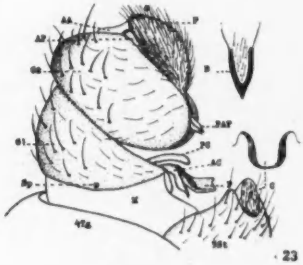

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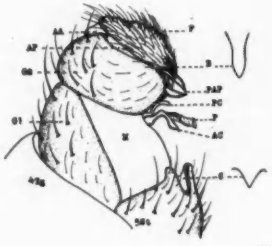

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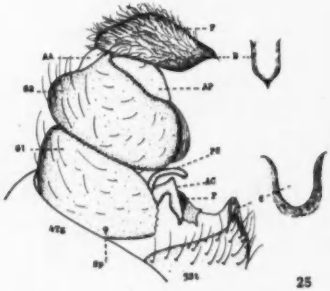

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FIG. 20. *Fabriciella nitida* v. d. W.
FIG. 21. *Fabriciella latiforceps* Tot.
FIG. 22. *Fabriciella emarginata* Tot.
FIG. 23. *Fabriciella piceifrons* Tns.
FIG. 24. *Fabriciella hispida* Tot.
FIG. 25. *Fabriciella ampliforceps* n.sp.